

Let's Walk Up and Play!
Design and Evaluation of Collaborative
Interactive Musical Experiences
for Public Settings

Benedikt Bengler

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Degree of Doctor of Philosophy

Centre for Digital Music
School of Electronic Engineering and Computer Science
Queen Mary University of London

Statement of Originality

I, Benedikt Bengler, confirm that the research included within this thesis is my own work or that where it has been carried out in collaboration with, or supported by others, that this is duly acknowledged below and my contribution indicated. Previously published material is also acknowledged below. I attest that I have exercised reasonable care to ensure that the work is original, and does not to the best of my knowledge break any UK law, infringe any third party's copyright or other Intellectual Property Right, or contain any confidential material. I accept that the College has the right to use plagiarism detection software to check the electronic version of the thesis. I confirm that this thesis has not been previously submitted for the award of a degree by this or any other university. The copyright of this thesis rests with the author and no quotation from it or information derived from it may be published without the prior written consent of the author.

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Details of collaboration and publications: all research and contributions in this thesis and the associated publications are my own work. The research was supported by Dr Nick Bryan-Kinns within the scope of his role as my primary supervisor, and he is acknowledged as a second author in all related publications. Previous publications related to this thesis are described in Section 1.5.

Abstract

This thesis focuses on the design and evaluation of interactive music systems that enable non-experts to experience collaborative music-making in public settings, such as museums, galleries and festivals. Although there has been previous research into music systems for non-experts, there is very limited research on how participants engage with collaborative music environments in public settings. Informed by a detailed assessment of related research, an interactive, multi-person music system is developed, which serves as a vehicle to conduct practice-based research in real-world settings. A central focus of the design is supporting each player's individual sense of control, in order to examine how this relates to their overall playing experience.

Drawing on approaches from Human-Computer Interaction (HCI) and interactive art research, a series of user studies is conducted in public settings such as art exhibitions and festivals. Taking into account that the user experience and social dynamics around such new forms of interaction are considerably influenced by the context of use, this systematic assessment in real-world contexts contributes to a richer understanding of how people interact and behave in such new creative spaces.

This research makes a number of contributions to the fields of HCI, interactive art and New Interfaces for Musical Expression (NIME). It provides a set of design implications to aid designers of future collaborative music systems. These are based on a number of empirical findings that describe and explain aspects of audience behaviour, engagement and mutual interaction around public, interactive multi-person systems. It provides empirical evidence that there is a correlation between participants' perceived level of control and their sense of creative participation and enjoyment. This thesis also develops and demonstrates the application of a mixed-method approach for studying technology-mediated collaborative creativity with live audiences.

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List of abbreviations

CC	Continuous Controller (MIDI message type)
DCC	Design Can Change (exhibition name)
DMI	Digital Musical Instrument
FM	Frequency Modulation
HCI	Human-Computer Interaction
IMN	Interconnected Musical Networks
LFO	Low Frequency Oscillator
MCU	Microcontroller
MIDI	Musical Instrument Digital Interface
NIME	New Interfaces for Musical Expression
OCT	Overseas Chinese Town
OSC	Open Sound Control
PSU	Power Supply Unit
RFID	Radio Frequency Identification
TUI	Tangible User Interface
SPL	Sound Pressure Level
U	Rack Unit
V&A	Victoria and Albert Museum

Chapter 1

Introduction

1.1 Motivation

“Music appreciation mavens used to wield an old saw about the composer-performer-listener triangle. [...] In this model the composer is genius/author, the performer is genius/servant, and the listener respectfully adores both.”

Paul Lansky (1990), Composer

In the Western world, music has become an expert domain. The dominant ‘romantic’ culture of Western music still very much favours the concept of the individual genius who is gifted to actually *make* music, while the rest of us are relegated to the role of passive recipients and admirers who quietly sit in the dark auditorium. This strict separation may have evolved through the ways of how Western aesthetics and art tradition were dealing with the immense popularity of music - similarly to other art forms, music was elevated to the level of high art and established as an expert domain.

As a consequence, Western music became highly focused on results - the great composition, the unforgettable performance - rather than on the process of its making. Interestingly, the ‘sacred concept of composition’, which is prominent

in Western music, is given much less importance in most of the world's other musical cultures (Burnard, 2012b, p.8). Nevertheless, in the Western world, the concept of making music as an end in itself - as a casual, social and open-ended activity everybody can participate in; as an engaging and enjoyable way to interact with other people - has, for the most part, disappeared. Many people may also be intimidated by this dominant cultural conception and simply accept that they 'can't do music'. Burnard, for example, argues that due to music education's remaining focus on the 'masterwork' paradigm, as children progress through primary school they may change their understanding of music from something in which everybody can participate to something that requires a particular talent; as a result, their musical self-confidence declines to a greater extent than in other subjects (Burnard, 2012b, p.9). Moreover, this one-sided point of view establishes an a priori link between musical creativity and the demand for individual talent and professionalisation. Therefore, Burnard (2012a, p.37) argues that this limited, romantic understanding of musical creativity is 'outmoded' and must give way to a notion of multiple musical creativities: while including the high art approach, this view has room for many other manifestations of musical creativity. Similar to Lansky (1990), Burnard particularly emphasises the social and situated dimensions of these alternative forms of musical creativity which are linked with different cultures and contexts, as well as with new practices and objectives, especially those which arise from the use of technology. In his visionary essay, Lansky (1990) highlights the potential of digital technology to propel the social dimension of musical creativity:

“Musical systems now become ways to listen, perform and compose through the mind of another. Or perhaps of many others. [...] What is interesting is that it is now possible to incorporate the design of a social context in these activities. Musical survival now depends more on the appropriateness of this design to the music rather than the extent to which the music successfully occupies traditional venues. Consider sound installations, listening galleries, interactive systems,

recording, intelligent software, for example.”

(Lansky, 1990)

Today, nearly 25 years later, it is interesting to examine to what extent this technology induced ‘social turn’ has manifested itself in the musical mainstream. Without any doubt, digital technology has fundamentally transformed the way in which people consume and listen to music (e.g. O’Hara and Brown, 2005). The social aspect of this development is particularly evident in the variety of today’s ‘globally spatialized internet forms’ (Burnard, 2012b, p.8) with their digital and mobile music services and related social networks, which blur the lines between consuming, sharing, and providing music. Despite this drastic shift in music consumption, it could be asked whether technology has a similarly strong impact on the process of *making* music, and related forms of musical creativity. On the one hand, the advent of affordable digital technology has radically democratised music production by making it accessible and affordable to many. This is illustrated, for example, by the rapid development of electronic dance music from the 1990s onwards, fuelled by the availability of affordable music electronics and increasingly powerful personal computers (Bengler, 2011, pp.40-46).

On the other hand, however, while undoubtedly many more people have access to and make use of music technology, it appears that the general attitude towards musical creativity has not changed fundamentally. New technology-driven musical cultures, such as dance music, seem to have established role models similarly to traditional Western music. The DJ as a music star who ‘governs’ the crowds from above, or the prevalent (strongly results-focused) notion of the *producer*, seems to be very much in line with the ‘master’ paradigm of Western art music. In terms of music *making*, it appears that digital technology has contributed to individual and results-focused forms of musical creativity to a considerably greater extent than to open-ended, social and widely inclusive forms. Particularly when it comes to co-located, ‘offline’ activities (rather than online) for general audiences that allow for acts of co-creation and collaboration

in social contexts. This thesis investigates how to facilitate such *collaborative musical experiences* in public, real-world settings. The idea behind collaborative musical experiences is to make the traditionally exclusive experience of musical collaboration available to much broader audiences through the use of interactive technology. Considering music as an enjoyable social activity rather than an expert practice, this approach aims to enable people without formal musical training to experience being part of a creative, collaborative musical process. There are a small number of musical systems that have started to explore this scenario, many of which are reviewed in detail in Chapter 2. This thesis systematically builds on, contributes to, and extends this body of work.

Critical voices of researchers and practitioners in the field of public musical creativity have informed the formation of the research agenda of this thesis. For example, Machover (2002) notes that while many systems have succeed to initially attract novices “few have been able to make such systems ‘nourishing’ as well, capable of encouraging deeper exploration”. Jordà (2004) criticises that by “seeking to guarantee a complex or predefined musical output, many of these [systems] do not give to their interactors more than a couple of bits to play with.” By foreshadowing potential challenges, these notions prompt a number of interesting questions. Do existing approaches provide and demand too little from their audiences? How can musical interaction design provide general audiences with a taste of the spontaneity and depth that professional musicians experience after years of practice? In other words, how can such systems support the process of *making* rather than merely giving access to some carefully pre-produced material? Or more generally, how do people behave and interact in such novel interactive environments in public, real-world settings? These questions have informed and are embedded in the structured research agenda that is described in detail in the following sections.

1.2 Aim and Approach

The following section presents the overarching research question. Based on this overall question, two research goals are defined that are addressed in detail in this thesis. Finally, a brief outlook is given on the methodological approach that frames the research undertaken as part of this thesis.

1.2.1 Research Question

The overall question this thesis addresses is: *how to successfully design and evaluate interactive systems for walk-up and play scenarios that enable engaging collaborative musical experiences for broad audiences in public settings.*

The following section defines this question in detail and specifies the meaning of the terminology used.

The term *musical experience*, as used in this thesis, specifies the active participation in a creative process that involves making music or sound. While traditional musical terms such as *composing* or *performing* are mainly focused from a specific result of a musical process, the term *musical experience* refers to the *process of making* as an end in itself. The attribute *collaborative*, (discussed in detail in *Collaborative or Collective?*, pp. 39-40), refers to enabling a group of people to co-create a musical outcome within a scenario that supports mutual awareness between the players.

Walk-up and play qualities specify interactive systems that are designed for exhibition spaces such as galleries, museums, trade shows or festivals, where people can walk up freely and play without having prior experience. This also implies that players may co-participate with people they do not know and that different participants may join and leave the multi-person experience individually. The description of the main target group as *broad audiences* refers to the fact that public spaces such as museums attract people with a broad range of skills, interests, experience and age. This also suggests that large parts of the audience cannot be expected to have musical skills gained through formal

musical training. In addition, the notion of *broad audiences* takes into account that many visitors may have no prior knowledge or previous experience with interactive music technology.

The attribute *engaging* aims to describe the intended user reaction: the participants should enjoy playing with the system while feeling part of a collaborative process, remembering it as an experience they were actively involved in. Moreover, the claim of a *successful* design for public settings relates to the applicability to various real-world settings and conditions, rather than to very specific pre-conditions. This calls for a reasonable degree of adaptability to different contextual, social and cultural settings.

1.2.2 Research Goals

In relation to the overarching question, two focused research goals are addressed in this thesis, as discussed in the following two sections:

1. *Developing a descriptive understanding of collaborative musical experiences in public settings.*
2. *Examining the value of perceived control in collaborative musical experiences.*

Descriptive Understanding of Collaborative Musical Experiences in Public Settings

By means of the *collaborative musical experience* developed in this thesis, the first goal is to inform a descriptive understanding of how people interact and engage with new music-based collaborative environments within real-world contexts. Studying large numbers of participants while taking into account social and technical aspects aims to contribute to a general understanding of audience interaction with collaborative experiences. This then could be used to inform other designs intended to facilitate collaborative public creativity.

Despite the growing interest and use of public *interactives* in museums and art galleries within the last decade, there is still a limited amount of research on

how people engage and interact within these interactive environments in real world settings - particularly with regard to multi-user scenarios that allow for co-participation and collaboration (Heath and vom Lehn, 2008).

Whilst the existing research mainly relates to interactive artworks, and digitally augmented exhibits and information systems (e.g. Candy and Edmonds, 2011; Heath et al., 2002; Hornecker and Stifter, 2006; Marshall et al., 2011) this context-sensitive perspective has rarely been adopted for assessing interactive music systems for broad audiences. The review of relevant literature on public interactive music systems, as presented in Chapter 2, indicates a lack of *systematic* approaches for evaluating these new forms of musical interaction. Systematic, as used in the context of interactive art research (Bilda, 2011; Candy, 2014), refers to evaluation approaches that go beyond informal or small-scale user testing. They obtain their results from studying situated interactions in real-world settings in a principled manner, often involving large numbers of participants, as undertaken in this thesis.

The Value of Perceived Control in Collaborative Musical Experiences

The second research goal has two parts: 1) to design a collaborative interactive music system that emphasises each player's individual *sense of control*, and 2) to examine how this characteristic relates to their overall playing experience.

A main finding from the literature review, as presented in Chapter 2, is that problems reported from different studies appeared to stem from the same general issue: participants experienced a lack of influence on how their interaction manifests in the resulting musical outcome of the system. As discussed in detail later (see *What's My Sound?*, pp. 50-52), the feeling of being part of a collaborative process seems to be highly dependent on recognising and maintaining one's own contribution. In terms of system design, critical issues relate to players' difficulties in identifying their influence on the musical outcome, for example, due to high interdependency of players' actions (Weinberg and Gan, 2001; Weinberg,

2003) or the involvement of a large number of participants (e.g. Paradiso, 1999; Möller, 1997). On the other hand, designs that avoid these identification problems by restricting the interaction to pre-produced musical material (e.g. Laney et al., 2010; Robson, 2002) are criticised for undermining real opportunities for musical creation (Jordà, 2004; Weinberg, 2003).

Therefore, the design problem addressed in this thesis is how to achieve a deep level of interactivity, in order to open up real possibilities for collaborative musical creation, while supporting each participant’s individual sense of musical control. This design focus is used to investigate the potential association between participants’ perceived level of control and their overall experience in the interactive environment.

1.2.3 Methodological Approach

The evaluation of design and audience interaction is based on a mixed-method approach developed in close consideration of the research goals and the practical demands of execution in real-world settings. It adopts and combines qualitative and quantitative methods with a focus on contextual studies. The emphasis on contextual evaluation is based on the notion that users’ experience of a technology, as well as their social behaviour, is significantly influenced by the social and physical context in which they occur (Blomberg et al., 1991; Mackay and Fayard, 1997; Gaver, 1996). This considerably restricts the adequacy of laboratory based evaluations for assessing technology-mediated public creativity. Therefore, field and video-based observations are used to examine how people interact with the system and each other in real-world environments. These ethnographically informed practices are complemented with quantitative methods including self-report questionnaires and data logs that capture the users’ interaction with the system.

The rationale and decision-making process behind this mixed-method approach and a detailed description of the methods used are presented in Chapter 4.3. As the evaluation approach was initially developed for the first study of this thesis

(Study I, Chapter 5), the practical application of it is described as part of the corresponding chapter. For Study II and Study III the evaluation approach was adapted, based on the experience gained from Study I, and the demands of the particular study context. These amendments are introduced in the respective study chapters (Chapter 6, Chapter 7).

1.3 Contributions

This thesis is directly relevant to designers of collaborative interactive systems who aim to facilitate public creativity, and to researchers and practitioners studying and evaluating public interactive environments. This thesis makes a number of contributions:

1. Empirical evidence across different socio-cultural contexts (Chapter 5, 6, and 7) that in collaborative music making there is a positive association between participants' perceived level of control and their sense of creative participation and satisfaction with the outcome (Chapter 8.1).

This is additionally corroborated by the analysis of interaction data which illustrates participants' attempts to facilitate clear recognisability of their personal musical contributions.

2. Empirical findings concerning social and contextual audience interaction around public interactive systems that contribute to existing research in HCI and interactive art. In particular to the as yet understudied area of collaborative multi-user systems for public creativity:

- Co-participation on a single instance of a multi-user interface is identified as the most common form of social participation. It is shown that the engagement process with such a system evolves to a significant extent *amongst* participants, especially in the early stages of participation (Chapter 5, 6, and 7).

- It is demonstrated that during participation, mutual observations lead to active exchanges of action between unacquainted participants (Chapter 7), and that initial engagement with the system typically evolves gradually from observing others to active participation (Chapter 5, 6, and 7).
 - It is shown that the duration of interaction of audience members with a public art system is largely determined by contextual and social factors, rather than by how they rate their interactive experience, and a number of triggers for leaving are identified (Chapter 5, 6, and 7).
 - It is demonstrated that participants' system interaction is considerably informed by their personal pre-disposition and experience (Chapter 6, and 7).
3. A set of design implications, derived from the three empirical studies of real-world audience interaction, which provide practical advice for designers of collaborative interactive music systems (Chapter 8.2), and show potential to also inform designs which are not based around sound or music (Chapter 8.3).
 4. A mixed-method approach for evaluating technology-mediated creativity in public settings that can inform and be adopted by other researchers. Particularly notable features are:
 - The application of an interactive arts research perspective on evidence-based approaches to audience evaluation for studying collaborative musical interfaces.
 - A novel approach of tightly integrating qualitative and quantitative methods for examining the interaction of live audiences.
 - Description of the systematic development of the mixed-method approach (Chapter 4), detailed descriptions of its application and adaptation to three different real-world settings (Chapter 5, 6, and 7), and a

detailed final assessment (Chapter 8.4).

1.4 Thesis Structure

This thesis builds on a comprehensive survey of related research into collaborative music systems (Chapter 2). This assessment informs 1) the research agenda and objectives of this thesis as presented in this chapter, and 2) the design of an original collaborative music system (Chapter 3), which then serves as a vehicle to investigate the identified research goals through practice-based research (Chapter 5-9).

Chapter 2

Chapter 2 provides a comprehensive review of previous research into collaborative music systems for general audiences and discusses the related research areas of New Interfaces for Musical Expression (NIME) and interactive art research. Based on review and critical assessment, a number of design considerations are identified that inform the development of an original interactive music system as part of this thesis.

Chapter 3

Chapter 3 presents how the identified design considerations are translated into a design concept for a collaborative interactive music system called *Polymetros*. The rest of the chapter describes the systems technical implementation, design iterations, and how *Polymetros* has been adapted to be used as a research tool.

Chapter 4

Based on a review of relevant research in Human-Computer Interaction (HCI) and interactive art, Chapter 4 develops the methodological approach employed in this thesis, by closely considering the specific research goals and related practical demands.

Chapters 5, 6, and 7

Chapters 5, 6, and 7 present and discuss the three empirical studies conducted for this thesis. In order to pursue the research goals of this thesis, these were carried out as contextual field studies with live audiences in real-world settings consisting of: 1) the Victoria and Albert Museum (V&A) in London, UK (Chapter 5), 2) the ‘Design Can Change’ (DCC) New Media Art Exhibition in Shenzhen, China (Chapter 6), and 3) the Sónar Festival 2013 in Barcelona, Spain (Chapter 7).

Chapter 8

Chapter 8 draws together the findings of the three studies and provides a structured overview that discusses interactive, contextual, social and cultural aspects. In addition, it relates the findings to previous research and discusses and evaluates the methodological approach used in this thesis.

Chapter 9

Chapter 9 summarises the findings of the three studies, recapitulates the contributions, refers to limitations, and concludes the thesis with potential avenues for future works.

1.5 Associated Publications and Presentations

Publications:

Bengler and Bryan-Kinns (2014a). In the wild: Evaluating collaborative interactive musical experiences in public settings. In Candy, L. and Ferguson, S., editors, Interactive experience in the digital age: Evaluating new art practice, Springer Series on Cultural Computing, pages 169-186. Springer, London.

This book chapter focuses on the methodology and evaluation approach as developed in this thesis and refers to methodological considerations (Chapter 4), a detailed description of the methods and data collection (Chapter 5.4) and the results of Study I as presented in the thesis (Chapter 5.5). This chapter is

referred by Candy (2014) as an example of how, in live situations, quantitative measures can be used along with observational data. It is also discussed in detail as an example for practice-based ‘in vivo’ evaluation (Candy, 2014, pp. 43-44).

Bengler and Bryan-Kinns (2013). Designing collaborative musical experiences for broad audiences. In Proceedings of the 9th ACM Conference on Creativity & Cognition (C&C '13), ACM, New York, NY, USA, 234-242.

This conference paper summarises design rationale and the system description of *Polymetros* (Chapter 3) based on the literature review (Chapter 2). It presents a main part of the findings of Study I at the V&A (Chapter 5).

The paper was awarded *First Honourable Mention for Best Contribution to Creative Communication 2013 at ACM Creativity and Cognition 2013, Sydney, Australia.*

Bengler and Bryan-Kinns (2015). “I could play here for hours..” (thinks the visitor and leaves): Why People Disengage from Public Interactives. In Proceedings of the 2015 ACM SIGCHI Conference on Creativity and Cognition (C&C '15). ACM, New York, NY, USA, 177-180.

Based on the three in-the-wild studies undertaken in this thesis, this paper examines factors that influence how long audience members actively engage with an interactive installation in public settings.

Supplementary publications:

Bengler and Bryan-Kinns (2014b). Polymetros. ACM Interactions 21(3), 12-13.

Kim, S., Kim, J., Lee, S. Petkov, I., Ronchi, G., Benghi, C., Bengler, B., and Bryan-Kinns, N. (2014). Demo hour. ACM Interactions, 21(2), 10-13.

Presentations:

21st January 2014: Invited talk: “Exhibition Spaces as Interaction Lab - Evaluating interactive experiences in real-world settings.” at Digital Futures, Victoria

and Albert Museum (V&A), London.

17th December 2013: “How do we evaluate that? Developing evaluation strategies for interactive music systems” at Digital Music Research Network Workshop 2013 (DMRN+8), Queen Mary University of London.

Selected Exhibitions:

7th August 2014: Polymetros exhibited at *Post Digital?* at Degree Art Gallery, London, UK

13th -16th October 2013: Polymetros exhibited at *London Innovation Showcase* at Yang Gallery, Beijing, China.

12th -15th June 2013: Polymetros exhibited at *Sónar 2013*, Barcelona, Spain.

12th -19th May 2013: Polymetros exhibited at *Design Can Change!* International New Media Art Exhibition, Shenzhen, China.

22nd - 23rd September 2012: Polymetros exhibited at the *Digital Design Weekend*, Victoria and Albert Museum (V&A), London.

Chapter 2

Background

This chapter sets out the research topic of this thesis. It provides a thorough and comprehensive review of previous research into collaborative musical systems for general audiences. Based on a critical assessment of the findings, a number of design guidelines are identified in order to inform the design of an original system that builds on existing research (Chapter 3), and serves as a vehicle to conduct practice-based research in real-world settings (Chapters 5-9).

2.1 Public Interactive Musical Experiences

This thesis investigates how to design and evaluate interactive systems that aim to convey the experience of collaborative music-making to public audiences. This overarching topic is related to two research fields in particular: firstly, it is closely aligned with interactive art research which investigates the creation and evaluation of interactive experiences and audience participation (e.g. Candy and Ferguson, 2014; Candy and Edmonds, 2011) and, secondly, as the interaction is themed around music, there is overlap with research on New Interfaces for Musical Expression (NIME) ¹. NIME explores new ways of how to use technology for musical interface design.

¹NIME conference series: <http://www.nime.org/> (Retrieved December 18, 2014)

To illustrate the common ground, a brief review of both fields is provided in the following.

2.1.1 Interactive Art

“I am an interactive artist; I construct experiences.”

David Rokeby (1998)

One of the earliest systematic definitions of interactive art was established by Cornock and Edmonds (1973). Their framework of ‘process-oriented’ art classifies artworks depending on the “relationship between the artwork, artist, viewer and environment” (Edmonds et al., 2004). Besides the categories ‘static’, which refers to any unchanging work of art, and ‘dynamic-passive’, which describes works that change over time autonomously (e.g. kinetic art), they introduced the category ‘dynamic-*interactive*’. A dynamic-interactive system is characterised by establishing a feedback loop with its viewers, who then become active *participants* that can influence the artwork through their action. Therefore, in interactive art, “audience participation is an integral part of the artwork” (Edmonds, 2011). It has to be experienced by action, since its understanding and value mainly arises from the interaction itself (Edmonds et al., 2006). Similarly, Rokeby (1998) argues that the creation of interactive art *is* the construction of experience. Hence, the challenge for the artist or designer is to ‘orchestrate’ this action-perception loop (cf. Norman’s (1990, p. 47) action cycle) in order to evoke the experiences that the artwork is intended to convey to its participants. A second, more general concern is how to engage audiences to become active participants in the first place, and how to encourage them to maintain their interest beyond initial encounters and share it with others. In their model of creative engagement, Edmonds et al. (2006) describe the attributes that are related to these different aspects of audience engagement as ‘attractors’, ‘sustainers’, and ‘relaters’. Attractors draw the audience’s interest, sustainers maintain their engagement, and relaters encourage them to come back or recommend it

to others.

Bilda (2011; Bilda et al., 2008) has developed a model of the engagement process which identifies four phases of interaction involving a number of different action modes. In the first two phases, ‘adaptation’ and ‘learning’, participants gradually develop their expectations and understanding of how the system works, while progressing from *unintended* and explorative to more *deliberate* actions. In the following phases, ‘anticipation’ and ‘deeper understanding’, the participants learn to predict the outcomes of their interaction, and their *intended* actions eventually lead to a sense of being *in control*. Some works may also evoke *uncertain* or *unexpected* modes, which occur if participants discover new aspects of the artwork or re-evaluate their initial expectations due to encounters during their interaction.

Other frameworks for interactive art include Costello’s ‘pleasure framework’ (Costello and Edmonds, 2009a, 2009b), which focuses on the design of playful experiences by considering different characteristics of play, and Fels’ (2000, 2004) model of embodiment, which conceptualises the participant’s engagement process with an interactive artwork through the lens of embodiment.

In this thesis, Bilda’s (2011) and Edmonds et al.’s (2006) models of engagement are especially useful frameworks with respect to the research focus, and are referred back to later (Chapter 8). However, it is to be noted that all frameworks mentioned are primarily concerned with interaction by a single user. Therefore, due to the explicit focus on collaborative participation, this thesis assesses and extends these models in a multi-user context. As an example, whilst Bilda et al. (2008) describe the engagement process as a “transformative dialogue between the participant and the art system”, this thesis shows that in multi-user situations, a significant part of this dialogue occurs *between* participants. Evaluation approaches used in interactive arts research are outlined and discussed in Chapter 4.2.

2.1.2 New Interfaces for Musical Expression (NIME)

The notion of collaborative musical experiences as a description for interactive music systems that focus on making collaborative music-making accessible to novices, has its roots in the NIME community. Blaine and Fels coined the phrase ‘collaborative musical experiences’ in their 2003 paper, which provides the first comprehensive overview of collaborative music systems for novices, many of which are reviewed in detail in the following section. Blaine and Fels (2003) classified these systems based on their different attributes (e.g. scale (number of players), physical interface, or musical genre), and concluded that the “the overriding similarity between [these] systems is that the overall experience takes precedence over the generation of music itself.”

Despite the fact that ‘collaborative musical experiences’ are rooted in the early NIME community (the conference series started in 2002), in recent years, the *Digital Musical Instrument* (DMI) paradigm has become most prominent within NIME research (Gurevich and Fyans, 2011). As defined by Wanderley (2001), a DMI consists of two independent units: a gestural interface and a sound generator which are related by *mappings* to specify how the user input controls the sound (e.g. Hunt et al., 2002). Whilst in general this definition is equally applicable to collaborative musical experiences, the crucial point is, however, that DMIs are widely considered to serve a similar role as acoustic instruments in a traditional performance context (Gurevich and Fyans, 2011).

Even though approaches focussed on novices or public audience participation are the subject of recent NIME research (e.g. Deng et al., 2014; Hindle, 2013), these are typically more concerned with interactive and technical aspects, rather than a *systematic* evaluation of the audience experience (see p. 18).

By contrast, a large body of the research - in particular with regard to evaluation - is concerned with the DMI paradigm based on the tradition of Western instrumental music where a single (often expert) player or ensemble performs *for* an audience. For example, O’Modhrain’s (2011) detailed overview of existing DMI evaluation frameworks shows that all approaches maintain the traditional

separation between performer and audience. The DMI is evaluated either from the perspective of the performer as active player and/or from the perspective of the audience, and how they perceive the interaction as passive spectators. This traditional duality is also reflected in recent, general NIME design frameworks (Jordà and Mealla, 2014; Morreale et al., 2014). Interestingly, the dominance of this paradigm is also criticised from within the NIME community itself (Gurevich and Treviño, 2007) as imposing “anachronistic and unnecessary constraints on the role of the digital system in music performance” (Gurevich and Fyans, 2011) by, for example, undermining musical-social contexts where “skill and genius are no longer the sole prerequisites for inclusion” (Lansky, 1990).

The focus of this thesis is on public interactivity, where the boundaries between performer and spectator are fluid. The study of how people interact within novel collaborative environments in real-world contexts, and therefore, the evaluation objectives have a strong leaning towards interactive arts research rather than DMI-focused evaluations. Hence, while this thesis draws extensively on NIME research to reflect on technical and interactive aspects of music system design, as presented in the following literature review, the adopted evaluation approach is mainly informed by interactive arts research. Chapter 4 outlines evaluation techniques for interactive art and discusses how these are informed by, and contribute to, evaluation methodologies from the field of HCI.

2.1.3 Research on Public Interactivity

Recent years have seen a growing interest within HCI and related fields for in-the-wild study of user interaction with interactive technologies in public spaces, most notably with and around large interactive displays and tabletop technologies. As discussed in detail later (see *Why ‘In the Wild’?*, pp.78-79), this is motivated by the view that lab-based studies are prone to omit important aspects that arise from real-world contexts of use (Rogers et al., 2007), illustrated by findings that situated characteristics of use differ from those previously identified in laboratory settings (Rogers et al., 2013; Marshall et al., 2011). There-

fore, whilst this thesis focuses in particular on collaborative music systems for museum and exhibition settings, it is aligned with this wider trend of studying public interactivity in real-world conditions. Hence, before focusing on music-related works, a short overview is given on contextual studies of interactive displays and tabletop applications, including museum and exhibition settings. Several studies have investigated the situated use of, and social organisation around, large vertical interactive displays in various public and urban settings featuring different interaction modalities. Applications include large-scale public multi-touch screens (Peltonen et al., 2008), billboard-style displays (O’Hara et al., 2008) and multi-display systems (Michelis and Müller, 2011) with gesture-based interaction, and displays combined with external input devices such as keyboards (Brignull and Rogers, 2003) or mobile phones (Scheible and Ojala, 2005). A seminal study is Brignull and Rogers’s (2003) in-the-wild evaluation of *Opinionizer*, a screen-based system aimed to encourage socialising in semi-public spaces. It consists of a large projection screen connected to a laptop, which people can use to type topical comments to be shared on the screen. Based on their observations of *Opinionizer* at two parties, Brignull and Rogers (2003) proposed a model of interaction flow around public displays. They identified three distinct stages of engagement or ‘activity spaces’ (peripheral awareness, focal awareness, direct interaction) which participants typically pass during their engagement process with the display, and suggest how this can inform a sufficient positioning of the system to encourage public participation. They also describe an observed social dynamic referred to as the ‘honey pot effect’. Groups of people who had already gathered around the display seemed to attract the attention of others, and it became much more likely that they also attended the display. Similar effects have also been observed around large-scale interactive displays in public, urban settings such as *Magical Mirrors* (Michelis and Müller, 2011) and *CityWall* (Peltonen et al., 2008). *CityWall* is a 2.5 meter wide multi-touch display allowing people to manipulate photo content, which was studied while being installed in a busy city centre street. Peltonen et al. (2008) describe

how peoples' interaction with the display enticed passers-by to gather around the display, and that people often approached it in a stepwise manner, similar as observed by Brignull and Rogers (2003). Multi-user interaction, which was found to be the primary type of interaction, was most commonly characterised by different users or groups (both strangers and acquaintances) working independently (in parallel), occasionally teaming up in joint activities or engaging in conflict management with others when their activities interfered due to the shared screen space. Michelis and Müller (2011) conducted an observational study of *Magical Mirrors*, a set of four large public displays, each 1.2m x 1.8m in size, with gesture-based interaction installed in a city centre. Showing a mirror image of the environment in front of them, the system reacted with optical effects to gestures of the audience. Based on their observations, Michelis and Müller (2011) proposed a framework aimed at describing audience interaction with gesture-based public displays. It describes the phases of passing by a display, viewing and reacting, subtle interaction, direct interaction, multiple interaction and follow-up action.

Offering different physical affordances than vertical displays (Rogers and Lindley, 2004), a number of studies have focused on public interaction with horizontal interactive displays, often referred to as interactive tabletops (see p. 41 for an overview of interactive tabletop technologies). For example, Marshall et al. (2011) studied the use of a shared tourist planner application based on a multi-touch tabletop installed in a tourist information centre. The application was designed to encourage groups of visitors to plan their town visit by independently selecting potential sites to visit, which then are presented to the group for joint review and discussion. The study showed that the presumption that acquaintances gather around and use an interactive tabletop together, as commonly assumed in lab-based studies, is not congruent with real-world use. Groups who arrived at the tourist centre together were often found to approach the tabletop at different times and members often left while others continued to interact. Other works on public tabletop use have considered dependencies

between interactive and non-interactive aspects of tabletop interfaces (O’Hara, 2010), or studied choice and use of gestures on large interactive displays (Hinrichs and Carpendale, 2011). Based on their study of participants’ interactional gestures with an interactive tabletop, Hinrichs and Carpendale (2011) proposed that gesture sets for public tabletops, in contrast to one-to-one gesture-action mappings, should be designed in close consideration of the interaction context (e.g. previous and subsequent gestures) and support alternative gestures for the same actions (many-to-one).

A growing amount of research is also concerned with how these technologies are used in museum environments (Geller, 2006). A number of studies have investigated aspects of social interaction and coordination around interactive, primarily screen-based museum exhibits (Hornecker, 2010; Heath and vom Lehn, 2008; Hinrichs et al., 2008; Meisner et al., 2007; Hornecker and Stifter, 2006). For example, Hinrichs et al. (2008) describe how acquaintances switched between active and passive roles to manage their access to an interactive visualisation system, which was not designed to be used by multiple users simultaneously. In keeping with findings of vom Lehn et al. (2001), Hornecker and Stifter (2006) describe how a digitally-augmented abacus was often used by groups working together, scaffolding each other by, for example, reading aloud the instructions of use from the exhibit’s screen. These group aspects are very similar to social configurations observed around large public displays, for example, Peltonen et al. (2008) reported that group members took up different social roles (e.g. teacher-and-apprentice) and negotiated turn-taking when interacting with the display. Other work has considered to what extent interactive exhibits were successful in conveying educational content. Hornecker’s (2008) observational study of *Tree of Live*, an interactive multi-touch table to browse information about natural history, suggested that due to a number of usability issues in combination with the employed interaction concept (information-browsing), visitors were mainly concerned with how to work the system rather than engaging actively with the theme and content presented.

In-the-wild studies of more explorative, or artistic-driven works have focused on eliciting user responses to open-ended interactive experiences (Morrison et al., 2011, 2007; Costello et al., 2005), aspects of bodily interaction (Freeman et al., 2013; Jacucci et al., 2009), and influences of physical space and social context (Akpan et al., 2013). In their study of *Iamascope*, a screen-based, interactive kaleidoscope triggered by participant’s movements, Costello et al. (2005) analysed participants’ verbal descriptions of their experience with the artwork (aided by a video replay of their interaction), and compared the responses to Fels’s (2000) proposed categories of embodiment. Freeman et al. (2013) studied players’ whole body interaction with *Tweetris*, a screen-based shape-matching game inspired by the video game *Tetris*, installed at a public art event. They analysed and classified the most successful player strategies, and investigated their relations to the possibilities of physical movement. Akpan et al.’s (2013) study of a public interactive display in multiple different locations indicated that rather than the physical space, the social context in which the work was presented had a higher influence on whether it encouraged people to interact.

In summary, as described above, in situ studies of interactive display technologies have explored a variety of aspects and applications, but it is their general insights on social coordination and organisation around public interactive systems that are particularly relevant to this thesis’ interest in investigating social and participatory aspects of public multi-person systems for collaborative music-making. Therefore, these findings will be considered later when discussing the results of the studies undertaken in this thesis in relation to existing research on social interactions around public interactive displays and similar applications.

2.2 Collaborative Music Systems for Broad Audiences

In recent years, a variety of collaborative musical applications have been designed which specifically address general audiences without formal musical training. Even though these systems may share similar general objectives, they differ significantly in terms of context, design approach and implementation. The following literature review gives a detailed overview and provides a structured, critical assessment of existing approaches. This will serve as the foundation for developing an original system design.

For reasons of clarity and readability, the reviewed applications are classified into categories, each of which subsumes systems with similar design characteristics. These categories are 1) Interactive Music Installations, 2) Musical Tabletops, 3) Co-located Physical Interfaces, and 4) Geographically Distributed Musical Applications. For each category, several representative examples are introduced and described. Subsequently, these are critically reviewed and discussed in a number of themed sections. Each reviewed category closes with a brief outline of the key issues and implications identified, which then are summarised at the end of the chapter to inform the system design in Chapter 3.

2.2.1 Interactive Music Installations

The term ‘Interactive Music Installation’ refers to an interactive art system for multiple users, which incorporates sound or music. These systems are typically designed for spaces such as galleries and museums, where audiences can wander freely through the exhibits. Since such contexts are generally intended to reach out to a wide public, the target audience is characterised by a broad range of skills, experience, and age. Hence, it has to be assumed that large parts of the audience do not have musical skills gained through formal musical training, referred to as musical *novices* (Blaine and Fels, 2003).

Walk Up and Play

One of the first attempts to create an interactive musical experience for general audiences was Tod Machover's (1996) participatory musical installation *Brain Opera* premiered in 1996. This large-scale, interactive environment, themed around the work of the cognitive scientist Marvin Minsky, is still unique in terms of a touring multimedia production centred on collaborative musical experience. Before the performance, the audience was able to interactively explore the opera's musical material and experiment with sounds that were integrated in the ensuing play. This was accomplished by a collection of 'hyperinstruments' especially designed for musically untrained users. The term hyperinstruments was coined by Tod Machover at the MIT Media Lab in the mid 1980s referring to instruments that use technology in order to expand their expressive capabilities². While the first augmented instruments were designed for professional musicians like cellist Yo-Yo Ma or Peter Gabriel, Machover started to develop hyperinstruments suited for non-expert players in 1991 (Machover, 1996). The instruments used in the *Brain Opera* were set up as 29 interactive stations of 5 different types which were distributed around an exhibition space called *Mind Forest*, through which visitors could wander freely. Each hyperinstrument, also referred to as an 'interactive experience' by Machover (1996), provided specific musical characteristics in order to allow visitors to explore different musical aspects like rhythm, harmony and timbre. By utilising varied input devices and interaction strategies, the project illustrates several possibilities of how interactive technology can be used for creating sound installations. *Brain Opera's Speaking Trees* and *Singing Trees* share a similar design, based on voice input. While the former enabled the visitors to record their thoughts evoked by the exhibition, the latter used the visitor's voice as a control signal for a generative soundscape. *Melody Easel* and *Gesture Wall* allowed the user to interact with pre-composed audio-visual material via gestural interfaces. *Harmonic Driving*

²<http://opera.media.mit.edu/projects/hyperinstruments.html> (Retrieved January 10, 2015)

featured a unique, spring-based steering interface to explore its content. The *Rhythm Tree* provided 320 piezoelectric drum pads, organised into groups of 32 pads, designed for simultaneous multi-user interaction to generate a soundscape of percussion and voice samples. The exploration of this interactive environment was followed by a performance of three professional musicians, mainly based on the material presented in the *Mind Forest*. Although it was originally intended to integrate various materials produced by the audience beforehand into the actual performance, the inclusion was restricted to the recordings made with the *Speaking Trees* for practical reasons (Paradiso, 1999). In addition, people were able to participate remotely via the Java-based web application *The Palette* (Yu, 1996), which allowed online participants to collectively influence parameters of the hyperinstruments used on stage.

Another collaborative music installation, Christian Möller’s interactive installation *Audio Grove* (Möller, 1997), was commissioned by the Spiral Wacoal Art Center, Tokyo in 1997. The installation consisted of 56 upright steel poles of 5.5 meters height, arranged on a wooden circular platform, 12 metres in diameter. This ‘grove’ of steel poles provided an immersive environment the visitors could walk through. Each of the poles served as a touch-sensitive electronic sensor connected to the installation’s audio system. Through touch, each visitor triggered sound events, which contributed to an overall soundscape that resulted in a “harmonic whole whatever the conceivable combination of interactions” (Möller, 1997).

Similarly, the multi-site gallery installation *Global String* (Tanaka and Bongers, 2001) by Atau Tanaka and Kasper Toeplitz was based on haptic interaction with large-scale physical objects. The underlying concept was the creation of a giant musical monochord that connected players from two different locations over a large geographical distance. At both venues, a 15 meter long steel cable was installed that spanned the room diagonally from the floor up to the ceiling. The two physical cables were ‘connected’ via the Internet, which served as an intermediate section of one extremely long, musical string. Players at both

ends could excite the string and the cable’s vibrations were digitised by a combination of sensors. The resulting data controlled a real-time sound synthesis, based on a physical model of a vibrating string with the length corresponding to geographical distance between the venues. Audio and vibration data were sent via the network to the remote location where the sound was played back, whilst the other physical end of the string was actuated accordingly by an electromagnet. Furthermore, a video conference system was installed at both sites. In this way, a sonic, tactile and visual telepresence was provided, in order to connect each player with their counterpart. The *Global String* was intended to be a collaborative musical instrument that “could adapt to different levels of playing” (Tanaka, 2006).

Another interactive installation designed for a collaborative ‘walk-up and play’ experience was Einar Ask’s sound sculpture *Speaking Orbs* (Ask, 2001). The installation consisted of nine ‘orbs’ with a round opening, facing upwards, arranged in an circular manner. Inside each orb a photo resistor was installed measuring the incident light. If the participants blocked a certain amount of light by moving their hands over the orbs, midi messages were generated that triggered single sound events contributing to a lingering ambient soundscape. Ask (2001) reported that the installation appealed to people of all ages, providing an easy, accessible and joyful collaborative sound experience.

In addition to exhibition-oriented works, interactive nightclub systems can also be considered as Interactive Music Installations. These enable the audience to influence music, lighting or displayed visuals via sensor technology. Approaches range from distributed wearable sensors, measuring the movement of dancers (Feldmeier and Paradiso, 2001; Hromin et al., 2003) to a variety of interactive technologies directly embedded into the club environment, such as floor-mounted pressure sensors, cameras or break-beam sensors (Ulyate and Bianciardi, 2002; Cliff, 2006).

Understandability and User Experience

Even if the idea of collaborative musical experiences that are instantly accessible to a broad, general audience is appealing, there are several problems to be addressed. Without any guidelines available, it may be difficult for visitors to figure out how to interact with such unfamiliar artefacts. For example, it is reported that the team of the *Brain Opera* decided, after a few days of providing audiences unguided access to the *Mind Forest*, to offer a short lecture and a handout that described each interactive station, with the objective of “reducing confusion and significantly improving the quality of their Lobby visit” (Paradiso, 1999). Also Möller had to provide an additional guidance sheet for *Audio Grove* in order to ‘restore’ the intended sound characteristics if the installation was approached by a large group of people (Bullivant, 2005). Therefore, it seems realistic and appropriate to recognise strategies for initial guidance as part of the design, rather than expect that such novel interaction environments are intuitively understood by all participants. In particular, the system developed in this thesis strives to provide a deep level of interactivity, and therefore, initial guidance is considered part of the system design.

Collaborative or Collective?

Without diluting the *Brain Opera*’s seminal achievement to create an interactive musical audience experience on a large scale, it has to be noted that the collaborative aspects mainly resulted from the artful integration of its different parts into an overall experience, rather than from encouraging direct interaction between audience members. The *Brain Opera*’s technical director Joseph Paradiso remarked that “future research is needed to address the balance between overall and local experience” in order to achieve “any significant level of collective music expression” (Paradiso, 1999). Additionally, all interactive stations except the *Rhythm Tree* were focused on single-user interaction. However, due to the *Rhythm Tree*’s large number of spatially distributed sensors, it appears to have provided only a very loosely-coupled interaction between players, espe-

cially if many visitors interacted simultaneously. In this case it seems hardly possible to identify, and distinguish, between what each participant contributes to the sonic outcome. The same issue applies to Möller's *Audio Grove*, which allowed a large number of visitors to influence the generated soundscape simultaneously. Therefore, such scenarios might be more appropriately described as 'collective', since their sonic outcome is influenced by the group as a whole, and it often may be difficult to single out the effect of an individual participant. Collaborative interactions, by contrast, arguably demand for mechanisms that support mutual awareness between participants and allow them to recognise their co-participants influence on the co-created output. As a prerequisite, this calls for interaction scenarios designed for a restricted number of participants. *Speaking Orbs* supported such mutual awareness by providing only a small number of sensors arranged in a way that allowed for visibility of other participants' actions. The drawback was limited possibility for musical creation, as only nine binary sensors were available to gather input data. The *Global String* provided an even stronger connection between its players by exploiting the metaphor of a shared physical string supported by rich multi-modal feedback. While this specific setting established an intimate one-to-one interaction, it seems less appropriate for more than one player at each side. Interactive nightclub systems are also more appropriately characterised as collective rather than collaborative as they mainly focus on how audio-visual content is controlled by a group of club-goers as a whole.

Conclusion

In conclusion, the review of Interactive Music Installations highlights the importance of considering initial guidance as an entry point for general audiences to such novel interactive environments. Secondly, it has drawn a distinction between collective and collaborative interactive environments. Consequently, this thesis focuses on collaborative interactive systems designed for a restricted number of participants, characterised by supporting mutual awareness of action

and coordination between participants.

2.2.2 Musical Tabletops

The term Musical Tabletops refers to musical interfaces that are based on interactive table surfaces. The central approaches used for such environments include tangible user interfaces (TUI) and multi-touch technology. The general concept of TUIs is to make digital information tangible by representing it via physical objects. In this way, the user can access and manipulate the underlying data physically while “taking advantage of multiple senses and the multi-modality of human interaction with the real world” (Ishii and Ullmer, 1997). These physical objects are directly placed on the table and usually augmented with computer graphics. Multi-touch surfaces are capable of recognising multiple points of contact, which enables several users to simultaneously interact with a graphical user interface via touch input. While multi-touch technology dates back to the early 1980s (Buxton, 2007), its technological impact did not take effect until the mid 2000s. Fuelled by presentations such as Jeff Han’s demonstration of an 82-inch multi-touch system at a TED conference in 2006, which became one the most popular technology-related videos on YouTube (Penenberg, 2007), multi-touch technology gained mainstream attention in 2007 with the release of Apple’s iPhone. Even though TUIs and multi-touch are different in principle, both can be realised using the same tracking technologies. Therefore, commercial products like the Microsoft PixelSense³, as well as software frameworks such as reacTIVision⁴ or CCV⁵ allow for a seamless combination of both approaches.

Round Table Music

One of the first musical interfaces relying on the tabletop metaphor was Toshio Iwai’s *Composition on the Table* presented at SIGGRAPH in 1999 (Iwai, 1999).

³Microsoft PixelSense: <http://www.microsoft.com/en-us/pixelsense> (Retrieved December 13, 2014)

⁴reacTIVision: <http://reactivision.sourceforge.net/> (Retrieved December 10, 2014)

⁵Community Core Vision (CCV): <http://ccv.nuigroup.com/> (Retrieved December 10, 2014)

Designed for exhibition spaces, the artwork consisted of the four audio-visual environments *Push*, *Twist*, *Turn* and *Slide* - each presented as an interactive table. Using a mixed reality approach, every interface combined physical components like buttons or dials, with top projection that provided direct visual feedback in relation to the user's input. *Push* consisted of 36 buttons, arranged in a six-by-six grid where every node represented a musical note. These are triggered by four spot lights moving around the grid. Using the push buttons, the players could influence the direction of these spot lights at every node, and in that way create melodic variations by changing their travelling paths. *Twist* and *Turn* allowed visitors to influence visuals and sound playback via rotary controls, while *Slide* featured eight plates that could be shifted relative to each other, causing corresponding changes in the audio-visual feedback.

Another musical tabletop application based on a mixed reality approach was *Jam-O-Drum*⁶ by Blaine and Perkis (2000). The environment was based on a circular table with six embedded drum pads, which were projected onto from above. In contrast to Iwai's tabletop works, which were suitable for multi-participant interaction, but without encouraging collaboration in particular, *Jam-O-Drum* was designed with the explicit goal to "bring a group of people together for a collaborative approach to music-making" (Blaine and Perkis, 2000). The system design was inspired by a drum circle, serving as a metaphor for a participative musical group activity, abandoning the strict separation between performer and listener commonly found in Western music culture (Stevens, 2003, p.13). Via the drum pads, up to six participants can join in. As musically untrained users can not be expected to keep time as a group, Blaine and Perkis applied different strategies to interpret the input data in order to achieve a more coherent overall musical result. In one approach, the players' drum hits were rhythmically quantised to the next occurring beat onset. Other strategies utilised the pad input to control high-level parameters such as the volume envelope of pre-recorded drum loops, or to trigger consecutive events of a predefined

⁶Jam-O-Drum website: <http://www.etc.cmu.edu/projects/jamodrum/spring04/> (Retrieved December 13, 2014)

drum sequence. Due to the “chaotic interaction and lack of direction” in early testings, Blaine and Perkis incorporated a call and response scheme in order to “carefully orchestrate the experience” (Blaine and Perkis, 2000). Mediated by the computer, a call sequence was played, followed by visual cues, indicating whether the phrase had to be repeated by the whole group or a single player. According to Blaine and Perkis this turned out to be the most successful interaction scheme in terms of musical collaboration, attracting both novice and expert players. The *Jam-O-Whirl* (Blaine and Forlines, 2002) was a revision of the initial *Jam-O-Drum* environment, featuring rotatable disks around each drum pad, allowing for continuous parameter input. Restricting the numbers of players to four, the experiences created for the *Jam-O-Whirl* were based on a more game-like type of interaction. By adapting video games such as the arcade classic *Pong* to this four-player environment, the developers aimed “to create goal-oriented or directed activities that would encourage more communication and social interaction between the players” (Blaine and Forlines, 2002).

In 2002, the musical performance interface *Audiopad* introduced a new interaction paradigm to music computing, relying on visually augmented ‘pucks’ as input devices (Patten et al., 2002). The *Audiopad* was designed to be used by two people in a musical duo context. Based on MIT’s *Sensetable* hardware platform, it used RFID (Radio Frequency Identification) technology for object tracking on a top-projected sensor surface (Patten et al., 2001). A player could map a set of samples to each of the pucks. During the performance, players could switch between preassigned sounds, and apply and modify different sound effects whilst the playback volume was controlled in relation to the puck’s position on the sensing surface. In this way, the sounds could be dynamically arranged into a loop-based composition.

Another Musical Tabletop based on the same paradigm is *Reactable*, developed by the MTG group at the Universitat Pompeu Fabra in Barcelona from 2003 onwards (Jordà et al., 2005). Instead of RFID technology, it used computer vision to track interface objects via attached visual makers (‘fiducials’). The

initial goal was to create a “state-of-the-art interactive music instrument” for collaboration suitable for complete novices, as well as for professional electronic musicians, being intuitively usable without any instructions (Jordà, 2003). The system design was intended to place the user in complete control of the musical output, not being dependent on pre-produced material or presets (Jordà, 2003). The concept of *Reactable*, which later was also adopted in a mobile application⁷, relies on the metaphor of a modular analogue synthesiser where available objects represent different synthesis modules. These include audio generators such as oscillators or sample players, control modules like LFOs (Low Frequency Oscillator) and sequencer objects; as well as audio processors such as filters or delays. These modules can be dynamically patched together on the tabletop while their particular properties, mutual dependencies and the overall data flow are visualised via rear projection. In this way, several people can collaboratively build up a modular interactive musical environment for real time sound synthesis. In contrast to the rectangular *Audiopad*, the *Reactable* was intentionally designed as a circular tabletop in order to avoid “privileged points-of-view or points-of-control” (Jordà et al., 2007).

Less complex than the *Reactable*, *TOUCHtrack* was a multi-touch tabletop application enabling four users to develop a musical piece, where every person could trigger four pre-recorded audio loops (Xambó et al., 2011). The authors argue that this setting is beneficial “to engage advanced musicians as well as novices given the emphasis on collaborative interaction” (Laney et al., 2010).

Mapping and Musical Metaphors

The drum circle metaphor used in *Jam-O-Drum* has the potential to be applied to collaborative music applications generally, as it represents the open-ended, ‘democratic’ and social attitude of a collaborative musical process. However, while the idea of a drum circle is beneficial to inform the overall appearance of such a system in terms of layout and role allocation, *Jam-O-Drum*’s one-to-one

⁷<http://www.reactable.com/products/mobile/> (Retrieved January 30, 2015)

implementation, using drum pads as input devices, seems problematic. In order to avoid issues resulting from inaccurate timing, several mapping strategies were applied. The initial approach of quantising drum hits to the next beat onset failed since “even subtle quantization was perceptible and distracting for participants” (Blaine and Perkis, 2000). Therefore, the developers used the drum pad input as a control signal for pre-recorded audio material instead. It appears likely that the problems reported by Blaine and Perkis with respect to the different mapping strategies mainly stemmed from the fact that the users’ expectations were insufficiently reflected in the system’s response. Drawing on the *embodied metaphor* (cf. Antle et al., 2009) of a percussion instrument, not meeting the action-reaction expectation of causing an immediate, percussive event in response to the performed strike, may be perceived as distracting and lead to an unsatisfying user experience. Therefore, the way *Jam-O-Drum* incorporates drum pads could be considered inappropriate for novices. Aware that they were not “responding quickly enough to user feedback requesting more responsive controllers” (Blaine and Perkis, 2000), the creators addressed this issue in the redesigned *Jam-O-Whirl* as mentioned earlier. However, user interaction shifted towards a multi-player video gaming environment where musical output was a ‘by-product’ of the game-like, goal-driven interaction, rather than the main focus of it. Similarly, this applies to some of Iwai’s works such as *Push* or *Slide*.

Even if the *Audiopad* was not targeted at novices in particular, its concept of mapping samples directly to a particular physical object seems to be a natural and intuitive way to use TUIs in a musical context. However, format and projection layout restricted participation to two players.

Being by far the most flexible musical tabletop system described in this section, the *Reactable* comprehensively exploited the metaphor of a modular synthesiser system, allowing players to collaboratively create a musical environment on the fly. The cost of this flexibility was the complexity of the underlying concepts and their representations in the user interface (e.g. separate audio and control

streams). *Reactable* was a powerful, collaborative interactive playground for skilled electronic musicians (Xambó et al., 2013), and could well be imagined supporting less literate users in exploration of the basics of sound synthesis, in a practice-based, highly interactive manner. However, it seems less appropriate for impromptu collaborative music-making amongst novices in public walk-up and play settings, due to its interactive and technical complexity. For example, in a long-term, lab-based study with “expert musicians with theoretical knowledge about sound generation”, players were found to have initial difficulties “to discern the functionality of an object” (Xambó et al., 2013).

Relying on the metaphor of an audio player, *TOUCHtr4ck* offered each participant a set of four samples to be played on their local unit. While being easily understandable, the musical possibilities were highly restricted. As more “musical features, awareness and control features” were requested by the users (Xambó et al., 2011), the developers redesigned the environment, allowing users to record up to four samples, which were then immediately played back as audio loops. These could be mixed and filtered using shared controls. However, it is questionable to what extent this approach is still suitable for novices, as it may require considerable musical skill to obtain reasonable results through real-time loop recording.

Conclusion

In conclusion, the review of Musical Tabletops suggests that a tabletop setup is well suited for social, collaborative music-making. In particular, the metaphor of a ‘round table’ as a level playing field for all participants closely matches the defined requirements for *collaborative* interaction scenarios (see p. 40) allowing to support mutual awareness and coordination amongst players. It was shown that choice of input device (and related metaphor) must match both the participants’ skill level and typical expectations evoked by it. In general, this review illustrates that there is a balance to be struck between (over)simplicity and interactive and technical complexity, which suggests the tension which must be

managed when designing collaborative musical systems for novices.

2.2.3 Co-located Physical Interfaces

The following section provides a review of collaborative music applications designed specifically for novices, based on user interfaces that are composed of several physical components. These are either shared or distributed amongst the participants, who interact in the same physical space.

A Toy Symphony

Referred to as ‘sound toys’⁸, Robson created a series of sound objects based on simple physical interfaces designed for people “who do not see themselves as musicians” or “feel intimidated by traditional musical instruments” (Robson, 2002). Whilst some of these objects focus on single user interaction, the *Bullroarers* enabled a collaborative sound experience for several people, each provided with their own physical interface. The design was inspired by the bull-roarer, an ancient ritual musical instrument consisting of a carved slat of wood with a cord attached. By swinging it in the air, it produces a roaring sound with a pitch related to the speed of rotation. Robson’s adaptation featured an embedded sensor, the output of which corresponded to the rotation speed. The data was used to control musical parameters such as rhythmic density or filter cutoff. In this way, up to three people were able to modify a set of pre-recorded, synchronised audio loops.

The *Musical Trinkets* (Paradiso et al., 2001) took the concept of sound toys literally; consisting of a cast of plastic toy figures with passive RFID tags attached, a set of sounds and effects could be controlled by moving the objects over a circular reader. Each toy corresponded to a particular sound or audio effect whose characteristics were modified related to the object’s proximity to the reader. Using this set of musical toys, several users could explore the musical capabilities of the system. But the “highly constrained interface made it

⁸<http://dominicrobson.com/index.php?/recent/sound-toys/> (Retrieved December 14, 2014)

very limited as musical instrument” (Pardue and Paradiso, 2002) with an outcome that “often stays in too simple a sonic space [sic]” (Paradiso et al., 2001), a refined version was developed called *Musical Navigatrics* (Pardue and Paradiso, 2002). As well as detecting the object’s proximity to the reader, *Musical Navigatrics* also tracked its horizontal position. This resulted in an increased number of continuous parameters to control effects and tonal sequence, the 3D tracking approach allowing for more complex musical manipulations.

Based on the concept of interconnected musical networks (IMNs) that allow players “to influence, share, and shape each others’ music in real-time”, Weinberg (2005) developed several interactive music systems particularly aimed at musical novices. In contrast to INMs relying on complex network topologies designed for expert players in an art music context, Weinberg focused on the social and experience-related aspects of the concept in order to “facilitate collaborative musical construction through interdependent social interaction in a group” (Weinberg, 2003). The *Squeezables* (Weinberg and Gan, 2001) were a collaborative music system for three players, consisting of six squeezable gel balls with embedded pressure sensors attached to a small, round platform. By squeezing and pulling one elastic ball with each hand, players were able to control the musical output of the system. Each *Squeezable* had a different musical function. Consisting of one *soloist ball* and five *accompaniment balls*, the system provided different musical roles for each player. Accompaniment balls controlled particular musical parameters independently, the soloist ball controlled pitch contour of the melody, which could also be influenced by the other *Squeezables*. Whilst three of the accompaniment balls were mapped to timbre-related parameters such as LFO rate or filter frequency, the other two controlled higher-level parameters like arpeggiation and rhythmic variation of pre-recorded sequences. This combination of timbre-related and structure-related control parameters, with different levels of interdependency, aimed at facilitating an “enhanced yet controllable experience for novices as well as professionals” (Weinberg and Gan, 2001).

In contrast to *Squeezables*, which was based on synchronous interaction of all group members, the *Beatbug Network* (Weinberg et al., 2002) facilitated interdependency by allowing each player to make their own musical contribution, which could then be further modified by the other participants in a turn-based manner. Each player was provided with a bug-shaped, hand-held interface equipped with a drum pad and two bend-sensor antennae. In its most complex interaction mode, every player was able to enter a short rhythmical phrase, which was then sent to another player’s bug chosen at random. This person could decide whether to keep the received phrase playing and contribute their own pattern, or to transform the received phrase, using the antennae to modify playback speed, volume and timbre. After that, the transformed phrase was passed on to another player randomly selected by the system, who faced the same decision. In this way, all group members were able to contribute their own phrase while maintaining the transformations they liked. The system was introduced to children in a series of guided workshops and was featured in Tod Machover’s *Toy Symphony*⁹.

The Politics of Collaboration

As discussed earlier (see *Understandability and User Experience*, p. 39), initial guidance is vital to successfully initiate audience participation in such novel, interactive multi-user environments. However, if a successful interaction can only be achieved through active participation of a skilled mediator, the ‘democratic’, immediate access to such a system may be restricted, and its suitability for walk-up and play scenarios diminished. Weinberg identified this issue as being one of the main weaknesses of the *Beatbug Network* as “a set of of teacher-supported workshops were necessary for providing a full and rich experience” (Weinberg, 2003).

A related concern is that the active involvement of an expert may easily establish a musical hierarchy. When creating systems, especially for people who are not

⁹<http://www.toysymphony.org/> (Retrieved December 16, 2014)

musically trained, it may be considered counterproductive if the most skilled player - whether it is the facilitator or one of the participants - takes over the lead whilst others have to be content with a less prominent role. An example of this is *Squeezables*, where the most skilled participant controls the *soloist ball* while the other players are allocated to *accompaniment balls*. Jo and Tanaka's (2009) framework of musical participation, which maps sociological notions of participation (Arnstein, 1969) to open-ended music-making, refers to this as 'tokenism', since players have some influence on the outcome but the power to change the 'status quo' is held by others. In contrast to this, 'citizen power' constitutes that all participants can engage in changing the outcome together as a group. This alternative, in which all participants have equal opportunities to influence the musical result, is favoured in this thesis.

However, given that participants are likely to have different individual skill sets, this raises one of the main design challenges: how to provide less skilled participants with easy opportunities for musical influence, whilst offering additional possibilities for exploration to more skilled users?

What's My Sound?

Reflecting on what constitutes the satisfaction of making music, Tanaka (2006) argues that the musicians' satisfaction is directly related to the sense of how their actions manifest in the resulting music. This includes the direct feedback of the instrument as well as "the identifiability a musician maintains in feeling the contribution his part is making in an ensemble" (Tanaka, 2006). Tanaka calls this notion 'sense of musical agency', in keeping with the general idea of the 'sense of agency', which refers to the sense of control over one's own actions (Gallagher, 2000). Considering this concept with regard to a scenario involving musical novices clearly illustrates the challenge to be faced, when designing interactive technology that aims at transferring such an experience to a broad audience. Unlike an ensemble consisting of musicians who have spent years of training in order to control and shape their instrument's feedback into a

distinctive voice within the ensemble context, collaborative musical experiences can not rely on skills and practices that need to be developed over a long period of time. Therefore, interactive technology steps in to bridge these technical demands by facilitating musical control and interaction which is achievable for everyone.

A common strategy is the use of pre-produced musical material. Instead of enabling the *creation* of musical content, the system provides high-level control possibilities that allow participants to influence its musical output. Multi-person applications mentioned earlier that incorporate such a strategy include Robson's *Sound Toys* (Robson, 2002), the *Jam-O-Drum* system (Blaine and Perkis, 2000) and *Musical Navigatrices* (Pardue and Paradiso, 2002). Even though these systems differ significantly in terms of appearance and technology used, they share the same basic principle: each participant's interaction is mapped to a high-level parameter, allowing them to modify a particular element of a pre-composed sound set.

A common critique of such approaches is that the user's possibilities to shape the musical outcome often are strongly restricted in favour of an intended, predetermined output. Jordà (2004) argues that by "seeking to guarantee a complex or predefined musical output, many of these [systems] do not give to their interactors more than a couple of bits to play with". On a more general level he concludes that "faked or useless interactivity is the blot of contemporary Interactive Arts! [sic]". Weinberg (2003) criticises many novice systems for not allowing their players to "truly contribute meaningfully and creatively to the composition, but rather they are only allowed to manipulate and control pre-composed material". Therefore, Weinberg prioritised this issue specifically in *Beatbug Network* (Weinberg et al., 2002), where the musical output was entirely based on musical motifs contributed by individual players. Each participant was equipped with their own physical interface which emphasised the significance of every player within the democratic, collaborative context. In addition, Weinberg's systems are strongly characterised by facilitating interde-

dependencies among the players which is intended to deepen the musical and social experience through mutual modifiability of other player’s contributions. This network-inspired approach reveals an interesting perspective on the relevance of a personal contribution in such environments. Informed by his design experiences, Weinberg recommends to restrict the level of interdependency in order to avoid “uncertainty about the individual control of each player” (Weinberg and Gan, 2001). Hence, a player should not be able to modify a peer’s phrase beyond recognition, as its creator might experience a loss of control and influence on the overall musical result. This can make players “feel disconnected from the music they created, as their detailed idiosyncratic contribution might be eliminated” (Weinberg, 2003). These recommendations closely correspond to Tanaka’s concept of musical agency and highlight the importance of providing players with opportunities to create and maintain clearly identifiable contributions within a collaborative musical context. Therefore, this thesis recognises the support of a clearly identifiable, individual contribution for each player as being a central design principle for collaborative musical experiences, which holds out the prospect to be an important factor for conveying the feeling of being part of a collaborative, creative process.

Conclusion

In conclusion, this review of Co-located Physical Interfaces has informed the decision made in this thesis to establish interactive settings in which all participants have equal opportunities for musical influence, recognising the related design challenge of accounting for different levels of skill. It has also highlighted the importance of supporting each participant’s individual sense of control as a promising design principle for interactive collaborative musical experiences. As a result, this principle is central to the interactive system design reported in the following chapter, while its implications are examined and assessed in the three main studies of this thesis (Chapter 5, 6, and 7).

2.2.4 Geographically Distributed Musical Applications

Apart from Tanaka’s multi-site installation *Global String* (Tanaka and Bongers, 2001) and the web-based application *The Palette* (Yu, 1996) as used in the *Brain Opera*, all systems (Weinberg, 2003) have been designed for a group of users sharing the same physical space. However, a variety of applications have been developed to enable geographically distributed users to collaborate within a shared sonic space. Examples include systems which use mobile phones to enable remote co-creation, such as *Daisyphone* (Bryan-Kinns, 2004), *Daisyfield* (Bryan-Kinns and Sheridan, 2012) and *Malleable Mobile Music* (Tanaka, 2004); or browser-based applications such as *Public Sound Objects* (Barbosa, 2005), *Auracle* (Ramakrishnan et al., 2004), or *Plink*¹⁰. A general overview of concepts and development of network-based music systems can be found in Barbosa (2003).

Since the main goal of this thesis is to study how audiences interact and engage with collaborative interactive systems in the shared physical space of a public setting, geographically distributed applications are not reviewed in greater detail here.

2.3 Summary

In this chapter, the research topic of this thesis has been situated within the field of interactive art, with some overlap into NIME research; and a brief overview of these research areas has been provided. A thorough review of existing collaborative musical systems for general audiences has been presented, and a representative selection of approaches has been described and discussed in detail. Based on critical assessment of the different categories reviewed, a number of implications have been identified that are considered relevant as design objectives for the original system developed as part of this thesis. This strategy was chosen in order to build on existing research while being sensitive to and

¹⁰<http://www.dinahmoe.com/lab-projects/plink/> (Retrieved December 16, 2014)

account for the overall research question this thesis is concerned with (see p. 16).

In summary, the design objectives for this thesis are to:

- support and sustain each participant’s individual sense of control,
- allow for mutual awareness and coordination amongst participants,
- provide equal opportunities for musical influence,
- support the creation of idiosyncratic musical content, and
- recognise initial guidance as part of the experience.

The following chapter reports how these objectives were implemented, and describes features and technicalities of the designed system.

Chapter 3

Polymetros -

A Collaborative Interactive Music System

The first section of this chapter describes how the findings of the literature review were synthesised into a design concept for a collaborative interactive music system called *Polymetros*. This will be then used to investigate the research goals of this thesis (see p. 17) in three public audience evaluations as reported in Chapter 5, 6, and 7.

The second part of the chapter gives a detailed account of the system's technical implementation, its design iterations, and how it was adapted to serve as a research tool.

3.1 Design Concept

One of the main design goals was to find a design approach for a collaborative interactive music system that emphasises each player's individual sense of control. The main difficulty was to develop a feasible concept which enables a novice

to make and maintain a personal, identifiable musical contribution in a multi-player context that also ‘harmonises’ with the other participants’ contributions. In contrast to Weinberg’s *Beatbug Network* (Weinberg et al., 2002), where each participant’s contribution was successively facilitated by the system or a defined score, the context chosen of an open-ended, walk-up and play scenario demanded for simultaneous and continuous contributions by all participants. Hence, each participant’s contribution needs to be an ongoing musical process, which ideally is easy to learn and control, but at the same time should offer enough possibilities to remain interesting for longer periods and cater for more experienced participants. Therefore, approaches that are entirely based on pre-produced audio content, which then can be solely manipulated on a ‘macro-level’ (filters, audio effects, etc.) are considered inappropriate. Although this strategy allows for clearly identifiable sonic interventions for each participant, it seems likely to quickly lose its appeal because of the restricted creative possibilities. In addition, due to the focus on general audiences, concepts and terminology specific to sound and music technology were avoided.

Therefore, an interaction concept was considered that relies on basic musical properties such as pitch, rhythm and timbre. Whilst using these commonly understood properties appeared promising, it posed a general design challenge: how to enable novices to create their personal musical contribution on a basic musical level, whilst also allowing for collaboration in a way that manages the tension between ‘cacophonic chaos’ and oversimplicity, caused by highly restricted possibilities? Through the process of assessing and refining this concept, the idea emerged to use *Minimal Music* as an inspirational basis for the system design.

3.1.1 Inspired by Reich and Riley

Minimal Music refers to a musical style mainly associated with composers such as Steve Reich, Phillip Glass, Terry Riley and La Monte Young, originating in the 1960s in North America (Mertens, 1983). The genre is characterised

by the use of short repetitive musical phrases that are gradually modified in length, time signature or melodic shape. This leads to procedural transformations of the resulting music that often maintains a stable harmony while the main interest lies in the perceptible process itself (Reich, 1968). As described by Phillip Glass, *Minimal Music* “no longer has a mediative function, referring to something outside itself, but it rather embodies itself without any mediation” (Mertens, 1983). This conception of music without an inherent meaning to be ‘deciphered’, as it manifests itself simply by being played or being listened to, closely relates to the idea of a *musical experience* as defined earlier (see p. 15). The music is often characterised as having ‘hypnotic’, ‘trance-like’ qualities causing a sense of timelessness. In addition, *Minimal Music* implies a ‘democratic’ attitude towards players as well as musical material: there are no soloists or lead instruments, and no sound has any greater importance than another (Mertens, 1983).

Since these qualities, the musical structure and the underlying techniques of Minimal Music closely correspond to the musical experience aimed to be conveyed, the decision was made to use specific properties of this musical ‘expert-domain’ to inform the design of an interactive system for a broad audience. In practical terms, the design aims to enable each player to create and control a repetitive musical phrase which becomes *their personal contribution* to the co-created musical output. Even though the players’ individual phrases are rather simple on their own, their polymetric interplay emerges into a complex and continuously evolving musical structure. Besides editing the actual notes of the motif, the players should be enabled to dynamically change tempo and time signature, add and remove notes/rests, or shift their phrase by a metrical entity in relation to their co-players’ contributions. Inspired by minimalist composing techniques, these interventions allow the participants to continuously create new variations and modify their contributions in a way that results in distinct alterations in the overall musical output.

In this way, the chosen strategy aims to account for the identified design ob-

jectives (see p. 54), which are to support each participant’s individual sense of control, to provide equal opportunities for musical influence, and to allow for the creation of idiosyncratic musical content (rather than manipulation of pre-produced material). The objective to support mutual awareness and coordination amongst players was addressed by using a ‘round table’ layout that provides mutual visibility, a design feature that was also prioritised in the user interface design.

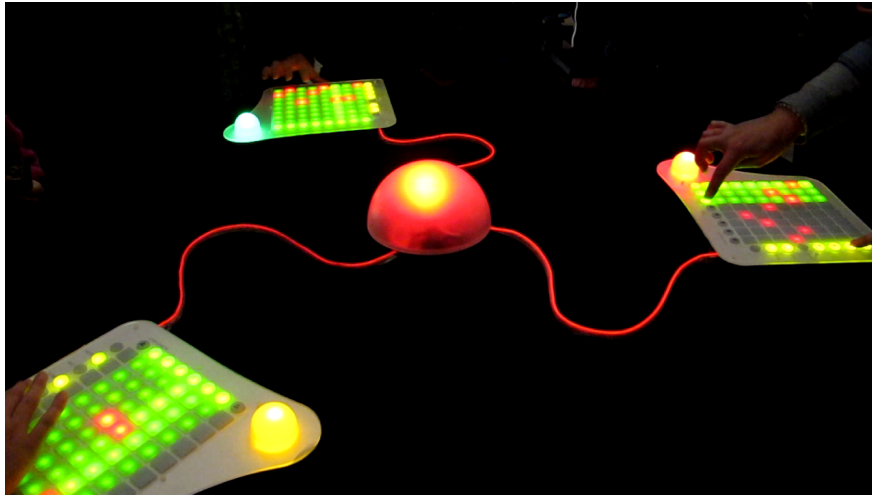


Figure 3.1: Polymetros in use

3.2 System Description

The following sections describe how the design concept developed was implemented technically.

3.2.1 User Interface

As shown in Figure 3.1, the user interface of *Polymetros* is composed of three individual hardware devices that are connected to a central hub in a star-like topology. Each participant controls one device which features a grid of soft buttons with embedded, tri-colored LEDs. These devices are referred to as

instruments as shown in Figure 3.2. The instruments are circularly arranged on a round table with a built-in audio amplification system.

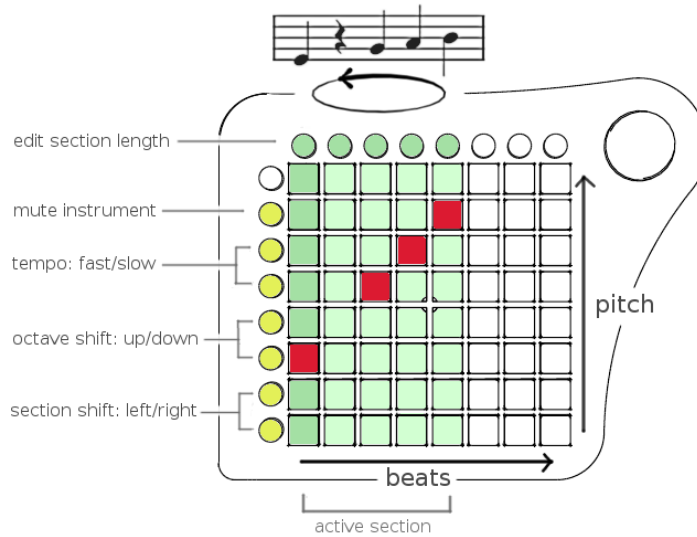


Figure 3.2: A single instrument of Polymetros

Each player can create and edit their musical phrase via an 8 x 8 button matrix, where the x-direction corresponds to time steps in beats and the y-direction to the pitches of a chosen musical scale. In the studies reported in this thesis, a natural minor scale was used. For each step, one note at a time can be set (and reset) by pressing the corresponding button, which allows for creating monophonic melody phrases. Following a loop-based concept, this phrase is continuously played back on repeat, while the actual playing position is indicated by a vertical ‘light bar’ moving horizontally across the grid.

Via the button row placed above the melody grid (labelled: ‘edit section length’ in Figure 3.2) the user can dynamically change the loop length by defining the active section of the grid. This allows for continuous creation of polymetric musical structures caused by different meters (loop lengths) of the players’ phrases, which are played back synchronously. For example, three patterns with the loop lengths of three, four, and five beats respectively would lead to a poly-

metric structure that repeats itself only after each sixty beats. The two round function buttons on the lower left (labelled: ‘selection shift: left/right’ in Figure 3.2) allow the user to shift the active playback section to the left or right, which can be musically described as discrete phase shifting. The other function buttons on the left-hand side allow the user to change the tempo to half-time, switch through different octave registers and dynamically mute the instrument’s output (on hold). All functions and states of the interface are indicated by visual feedback via tri-colour LEDs embedded in the buttons. Additional visual feedback is provided by each instrument’s cable connection to the hub which flashes up every time a note is triggered on its grid. The sphere-shaped hub serves as a visual centre, pulsing red in time with the beat as the metaphorical ‘heart’ of the system.

In the upper right, each instrument features a sphere-shaped dial that allows the player to influence the sound characteristics of the instrument by turning it clockwise or anticlockwise. The dial has a spring loaded snap-back mechanism which returns the dial to its neutral middle position (no sound change) after being released.

Each instrument has a different sound characteristic (described later in *Sound Sets*, pp. 67-69), and is played back through an individual speaker located behind the associated instrument, embedded in the table. The speaker system is hidden under stretched fabric which covers the tabletop, and is assembled in such a way that each speaker faces one particular player.

3.2.2 Implementation

Polymetros consists of a software application, a multi-user hardware interface, and additional audio equipment for sound synthesis, audio routing and amplification. A technical overview is provided in Figure 3.3.

The main software component is written in *MAX*¹, and runs on a small compact desktop computer. *MAX* is a visual programming language for computer

¹Max language: <http://cycling74.com/products/max/> (Retrieved December 16, 2014)

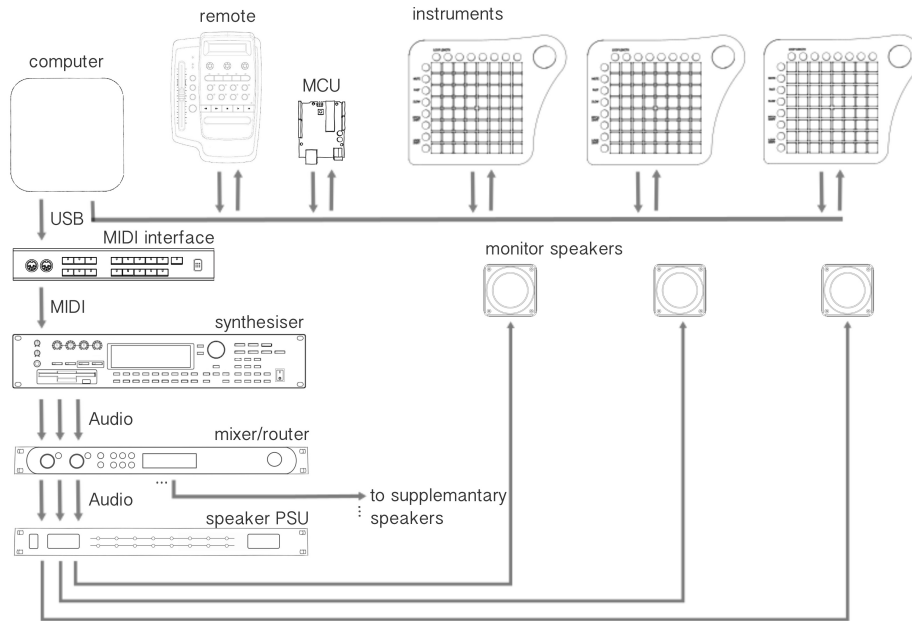


Figure 3.3: Technical overview

music and interactive media applications. The software implements the main system functions including the phrase generators, I/O mapping, and dedicated hardware drivers for the multi-user interface. It handles all global parameters such as tempo and scale, and controls presets and overall system execution. The application provides the musical output as MIDI data and transmits each instrument on a different MIDI channel. In this way, any internal or external MIDI device can be used for sound synthesis.

The instruments are custom-made devices built for the *Polymetros* system. In order to implement the illuminated tri-colored grid, the electronics and button overlays of a commercially available MIDI controller² were repurposed through custom written software. The instruments contain additional electronics for backlighting and position sensing of the rotary dials.

The enclosure was created using computer-aided design software and is composed of Acrylic (front plate) and Medium-Density fibreboard (chassis). The components were produced with a laser cutter. The dials' spring loaded snap-

²Novation Launchpad: <http://uk.novationmusic.com/midi-controllers-digital-dj/launchpad> (Retrieved December 16, 2014)

back mechanism was designed and assembled from custom-made plastic parts. Hardware/software communication is handled via a specific I/O wrapper³ that converts the manufacturer-specified MIDI control messages into a generic protocol, based on *Open Sound Control* (OSC). OSC is a high-resolution communication protocol for audio and multimedia devices, implementing a URL-like, symbolic naming paradigm⁴.

All instruments are connected to a powered USB hub housed within the sphere in the middle of the system. In addition, the sphere hosts a microcontroller board⁵ (*Atmel AVR*-based, labelled: ‘MCU’ in Figure 3.3), which reads the instruments’ dial positions and controls lighting of the sphere and illuminated USB cables. These are based on electroluminescent wire driven by three high frequency AC inverters. They are controlled from the main software application via the microcontroller.

Alongside these custom-made components, several commercially available audio devices were used for sound generation and distribution. In the first version of *Polymetros*, the instruments’ sounds were generated using external, MIDI-controlled synthesiser modules which were later replaced by software synthesisers. Both implementations are described in detail in the following (see *Sound Sets*, pp. 67-69). The embedded amplification system is based on a compact, high-quality distributed speaker system⁶, which provides a wide-range frequency response and has high sound pressure level (SPL) capability with very low levels of distortion.

3.2.3 Design Iterations and Sound Sets

The following section reviews the iterative development and refinement of the *Polymetros*, system with reference to the three studies reported in the thesis.

The main system changes relate to the methods of sound generation, the partic-

³wacLpHandler: <http://chippanfire.com/software/> (Retrieved December 16, 2014)

⁴OSC specifications: http://opensoundcontrol.org/spec-1_0 (Retrieved December 16, 2014)

⁵*Teensy* development board: <http://www.pjrc.com/teensy/> (Retrieved December 16, 2014)

⁶Meyer Sound MM-4XP speakers with MPS-488HP external power supply: <http://www.meyersound.com/product/mm-4xp/> (Retrieved December 16, 2014)

ular sounds used for each of the instruments (Sound Set) and the introduction of additional interactional features. Table 3.1 provides an overview of the system’s iterative development.

	Sound generation	Sound set/style	Additional features
Study I, V&A	Hardware Synthesiser	Minimal Music	-
Design Iteration 1 Study II, Shenzhen	Software Synthesiser	Minimal Music	Dials for timbre control
Design Iteration 2 Study III, Sonar	Software Synthesiser	I. Minimal Music II. Electronica/Techno	Drum machine instrument (for electronica sound set)

Table 3.1: Overview: Design Iterations

Sound generation: In the first version of *Polymetros* as schematically shown in Figure 3.3, the instruments’ sounds were generated using the external, ROM-based synthesiser modules *Korg Triton* and *Yamaha MU80*. These were controlled by the main software application via MIDI. Each instrument was synthesised with a different sound and the output was available separately on different audio outputs of the synthesisers. The outputs were connected to a digital mixing device (*MOTU 828 MkII*), which is capable of delivering and distributing different output mixes of the input material. This feature was used to accommodate the ‘dry’, sound-absorbent acoustic properties of the performance space used for the pilot study (described later, see pp.92-93) . In order to support each player in localising their instrument while providing a balanced sound impression of the overall musical output, each speaker played back the allocated instrument mixed with the respective other two, which were attenuated by 3dB. In the three main studies, however, the playback settings were adapted according to the changing acoustic conditions, and each speaker solely played back its allocated instrument. Due to the more lively acoustics of all three exhibition spaces, the instruments’ sounds blended together naturally while the separated

playback allowed for a better localisation of each instrument from the respective position of its player.

In the first design iteration (i.e. Study II), the hardware synthesisers and mixing unit were replaced by a combination of software synthesisers and a multi-channel audio interface. In this setup, sound generation, mixing and signal routing were accomplished via software, reducing the 19-inch rack space from 6U (rack units) to 2U. The primary reason for this change was to facilitate easier transportation. As Study II and Study III were conducted outside of the UK, the equipment had to be transported by plane, and size and weight of the system components became relevant factors. However, despite its considerable weight, the distributed speaker system was transported to ensure an equivalent, high-quality listening environment, and avoid potential compromises in sound quality and projection due to inferior quality substitute equipment sourced on-site. The second reason for replacing the hardware synthesisers was the demand for more flexible sound synthesis, which became evident when implementing the *Sound Dials* as described in the following section.

Sound Dials: In the first design iteration of *Polymetros* (i.e. Study II), the Sound Dials were introduced. Positioned in the upper right corner of the instrument, these sphere-shaped rotary controls allow modification of the instruments' sound characteristics in real-time. The Sound Dials were explicitly devised as an *additional feature* and are not essential for the basic interaction concept of the instruments. Their implementation was meant to complement the discrete, note-based interactional style with an optional, continuous control possibility that expands the instruments' sonic capabilities as well as the players' scope of action. It was driven by a particular interest in how such an additional 'high-level' control would be used and incorporated into participants' musical interactions.

The Sound Dials were implemented as bidirectional controls: from their neutral position (pointer line in central position) each dial can be rotated 120 degrees in

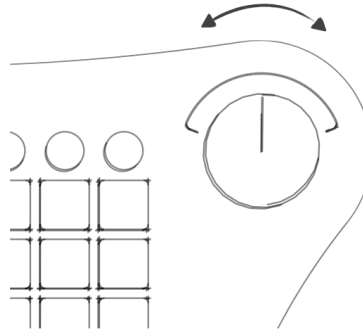


Figure 3.4: The Sound Dial

both directions (see Figure 3.4). While aiming to support the players' focus on their interaction with the dial by providing haptic feedback, the mechanism is of particular importance for recording the participants' interaction data for study purposes: it prevents the dial from remaining in a 'random' position when a participant leaves the instrument and ensures that each playing instance starts with the dial in its neutral position.

In terms of sound design, the challenge was to find control parameters that provided each player with a distinct and clearly noticeable effect of sound modification, without adversely affecting the playing experience of the other participants. Therefore, the dial's impact on each instrument's sound characteristic needed to be easily perceived in a noisy environment (e.g. a lively gallery space), without dominating the overall musical output. For example, clearly perceptible effects such as 'boosting' the volume or adding a significant amount of reverb or distortion would result in a considerable increase of the instrument's perceived loudness which could easily lead to auditory masking of the other instruments. This poses the risk that the other players experience difficulties in identifying their own contribution in the overall musical output, it being 'acoustically dominated' by another instrument. This counteracts the underlying design principle of *Polymetros* which is to support clearly identifiable contributions for all participants throughout their playing as discussed in detail earlier (see *What's My Sound?*, pp. 50-52).

Therefore, the aim was to implement a balanced effect parametrisation that provided a clearly perceptible effect without drastically changing the instrument's dominance in the mix. Given that the instruments in the minimalist inspired sound set were all based on different mallet and pitched percussion instruments (see *Sound Sets*, p. 67), the solution was found to be the manipulation of sound length and contour. Manipulating the sound's amplitude behaviour in time for each individual note resulted in a clearly perceptible effect on the instrument's sonic character: Whilst shortening the sound's decay led to an increasingly percussive and transient character, prolonging the decay time resulted in a more resonant and 'mellow' sound. Due to their percussive character, the main energy remained in the sound's onset rather than in the prolonged decay tail, and the masking effect on the other instruments was relatively low. An additional dynamic adjustment of the sound's volume (increase volume when sound gets shortened, decrease volume when sound is prolonged) compensated for the perceived changes in loudness and balanced the modified sound within the overall mix.

Implementing this approach revealed the limited capability of the sound modules used. As their synthesis is based on pre-recorded samples stored in the instrument's ROM (read-only memory), the sound can only be 'prolonged' by modifying its amplitude envelope, which is restricted by the length of the underlying sample. In most of the synthesisers' programs suitable for *Polymetros*, the underlying samples were not long enough to prolong the sound's decay phase by a significant amount. However, being systemic to sample-based synthesis techniques in general, this issue remained when testing (sample-based) software instruments. Therefore, instruments based on physical modelling synthesis were used to meet these requirements. Rather than using pre-recorded instrument samples, this synthesis technique is based on physical models that simulate sound production mechanisms such as vibrating reeds, bars, strings or membranes, taking into account their physical properties and behaviour (e.g. material and geometry, excitation mechanism and damping effects). Being well

suited to the synthesis of mallet-type and pitched percussion instruments, they allowed for drastic modifications of amplitude behaviour and sonic character, while each instrument’s basic, unmodified sound could be closely matched to the initial version of the sound set based on the hardware modules.

Sound Sets: The following two paragraphs specify the different sound sets as used in the studies and their characteristics.

	Sound type	Characteristics	Synthesiser	Program [preset]	Synthesis	Dial
Instrument 1	Pitched percussion	Drum-like, tonal, strong low frequency components	Korg Triton	Djembe/Log drum [D036]	ROM sound module	-
Instrument 2	Mallet/Electro-mechanical	Warm, solid, Epiano-like	Yamaha MU80	SineMrmb [64/13]	ROM sound module	-
Instrument 3	Bell/Mallet	Metallic, brilliant	Yamaha MU80	Marimba [0/13]	ROM sound module	-

Table 3.2: Sound Set I (a): Minimal Music

Sound Set I: Minimal Music: Apart from being suitable for the minimalist inspired musical theme, the main reason for choosing either mallet or pitched percussion-based sounds for all instruments was that their transposition over a wide pitch range allowed for versatile sound characteristics, ranging from drum-like sounds in low registers to bright, bell-like sounds in high registers. In addition, due to their transient character, dissonant dyads (e.g. 2nds or 7ths) between instruments did not ‘stand out’ as unpleasant. This allowed for the use of a natural minor scale, which led to a more interesting musical output compared to a pentatonic scale as often used in music application for novices in order to avoid dissonances.

Table 3.2 gives an overview of Sound Set I as devised for the first version of *Polymetros* used in Study I, where the sounds were generated with hardware

synthesisers (see Table 3.1). The table summarises the different sound types and characteristics of each instrument and specifies program name, bank and preset number of the synthesiser used. Note that the dial function was not yet implemented in this version.

	Sound type	Characteristics	Synthesiser*	Synthesis type	Dial effect [-/+]
Instrument 1	Pitched percussion	Drum-like, tonal, strong low frequency components	Sculpture	Physical modelling	Shorter, more percussive / Longer, more resonant
Instrument 2	Electro-mechanical piano/Mallet	Warm, solid Epiano-like	EVP88	Physical modelling	Shorter, more percussive / Longer, brighter, more resonant
Instrument 3	Bell/Mallet	Metallic, brilliant	Sculpture	Physical modelling	Shorter, more percussive / Longer, more resonant

* synthesisers are part of Apple's Logic Pro/Mainstage software package

Table 3.3: Sound Set I (b): Minimal Music

Table 3.3 shows the revised Sound Set I (b) as used in Study II and III, where the sound generation was based on software synthesisers (*Apple's Logic Pro Sculpture and EVP88*). In order to provide comparable conditions in terms of sound between the studies, the unmodified sounds (dial in neutral position) were programmed so that they closely matched the characteristics of the initial version of the sound set. The programmed instrument settings can be found on the CD-ROM included with this thesis (see Appendix E). Additionally, Table 3.3 lists the effects of the Sound Dials. For all three instruments, these were based on manipulating the decay properties of each sound type as described in detail earlier (see *Sound Dials*, pp. 66-67).

Sound Set II: Electronica/Techno: Table 3.4 gives an overview of Sound Set II, which was devised as an alternative configuration for Study III at the Sónar Festival, Barcelona. Reflecting the festival's musical focus, the sound set was inspired by electronic dance music.

	Sound type	Characteristics	Synthesiser*	Synthesis type	Dial effect [-/+]
Instrument 1	Kick Snare Closed Hi Hat Open Hi Hat Rim shot Low tom	Synthetic drum sounds as characteristic for analogue drum machines	Ultrabeat	Subtractive, Virtual analogue + Sampling	Duller, low-pass filtered/ Longer, increased decay phase
Instrument 2	Synth Bass	Saw wave based bass/lead sound as commonly used in electronica	ES M	Subtractive, Virtual analogue	Duller, low-pass filtered/ Brighter, more resonant
Instrument 3	FM Bell	Metallic, bell-like, airy	EFM1	Frequency modulation (FM)	Shorter, more percussive/ Longer, more resonant

* all synthesisers are part of Apple's Logic Pro/Mainstage package

Table 3.4: Sound Set II: Electronica/Techno

Whilst Instrument 2 and 3 were configured as monophonic melody instruments, as described in detail earlier (pp. 58-59), Instrument 1 allowed for the creation of drum patterns based on up to six different drum sounds. These were reminiscent of analogue drum machines, commonly used in electronic dance music (e.g. the Roland TR Series). The drum interface is described in the next section. Based on the experience of Sound Set I, shorter sounds were chosen for the melody instruments to minimise masking effects. These were an impulsive synth bass/lead sound (Instrument 2), and a short, bell-like effect/lead sound (Instrument 3). The dial effects combined decay time and timbre manipulations to allow for typical low-pass filter effects on drums and bass. The programmed patches for the three instruments used (*Apple's Logic Pro Ultrabeat*, *ES M*, and *EFM1*) can be found on the CD-ROM included with this thesis (see Appendix E).

Drum Instrument: Like the melody instruments, the drum instrument was based on a loop-based concept. The pattern created was played on repeat and the current playing position was indicated by a vertical bar moving across the grid. In contrast to the monophonic melody instruments, the drum instrument

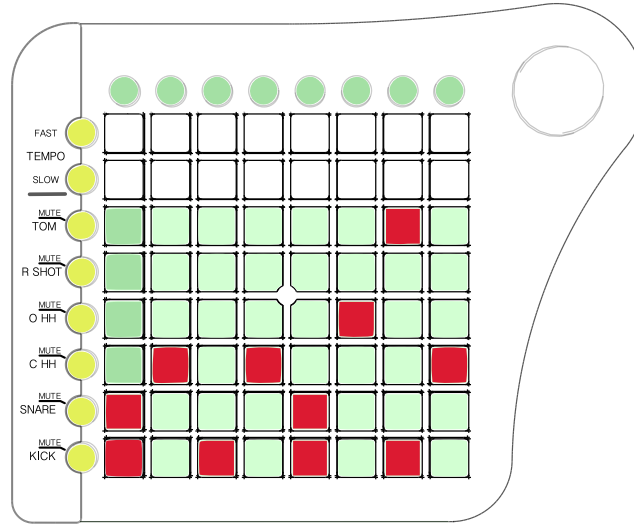


Figure 3.5: The Drum Instrument: typical dance music pattern.

allowed polyphonic drum patterns to be created, with each of the six active button rows mapped to a different drum sound.

As an illustration Figure 3.5 shows a typical dance music pattern. It consists of a 4/4 kick drum (bottom row), a snare drum on each second kick (second to bottom row), off-beat hi-hats (third and forth row), and single low tom on last kick drum (sixth row). With the buttons on the left-hand side of each drum row, each drum can be muted individually (on hold). Tempo change and modification of loop length (via topmost button row) are implemented identically to the melody instruments.

3.2.4 Polymetros as a Research Tool

This section briefly describes the additional functionality that was implemented in the *Polymetros* system in order to record, process and analyse participants' interaction data.

Data Logging: The data logging mechanism was directly integrated into the main software application controlling *Polymetros*. Via a MIDI controller (*Frontier Design Alpha Track*), data recording could be controlled remotely for all three instruments. During the studies, a unique ID code was generated for each log of recorded data (all input data made via the instrument’s interface). The two most recent ID codes of each instrument were displayed on a LCD monitor, which was placed clearly visible for all members of the research team. In this way, questionnaires completed by the players could be marked with the corresponding ID if a log file was created for this particular user. This supported the assembly of a matched data set of participants’ questionnaire responses and their recorded system interaction.

Data Processing: As part of data logging, the musical output of each instrument was also recorded individually and stored in a symbolic representation, similar to MIDI. All recorded events (user input and musical output) were timestamped in a 1/60th-second ticks per 24-hour clock format. This timecode was directly derived from the computer’s system clock, which served as an absolute time reference to anticipate ambiguities in case of a system crash or other temporary failure.

In the pre-processing stage, R^7 was used to format the recorded input data, and segment it into subsets, each corresponding to a single playing instance. In addition, the ID codes were used to allocate subsets to corresponding self-report data if a questionnaire has been collected for this instance. These subsets were then analysed and visualised via a software tool programmed in *Processing*⁸, based on a pattern recognition approach informed by observations during the studies. Pattern analysis and visualisation are described in detail in Chapter 5.5.2 (pp. 106-108).

⁷*R* is a programming language and environment for statistical computing and graphics. <http://www.r-project.org/> (Retrieved December 16, 2014)

⁸*Processing* is a programming language and development environment based on *Java* with a focus on visually oriented applications. <http://www.processing.org/> (Retrieved December 16, 2014)

3.3 Summary

This chapter presented the design concept of *Polymetros*, inspired by Minimal Music. It specified the system's technical implementation and gave a detailed overview of its interactive and musical features. It also reported how the system was equipped for data collection in order to study the participants' interaction with the installation.

Chapter 4

Evaluating Experience

This chapter develops the evaluation approach used in this thesis. First, it briefly reviews the recent trend in HCI research towards experience focused evaluation, and synergies between HCI and interactive art research - a research area that is closely aligned with the general objectives of this thesis. Drawing on this background, specific objectives, practical demands and related implications are examined and discussed, and the findings then are incorporated into a bespoke evaluation approach.

4.1 Experience and HCI

The shift in focus towards the experience of the individual, embedded in the sociocultural contexts of everyday life situations, has been described as the ‘third wave’ (Bødker, 2006) or ‘third paradigm’ (Harrison et al., 2006) of HCI. Starting from the early 2000s (e.g. Jordan, 2000; McCarthy and Wright, 2004), this development has more recently reached the mainstream of the HCI community (Candy, 2014).

Prior to this, the first wave of HCI (1980s) was primarily concerned with task-based evaluation of desktop interfaces by measuring aspects such as ease of use and objective performance. In the 1990s, the second wave emphasised the sit-

uated context of interaction beyond mere task level. The focus shifted towards design and evaluation approaches which account for the users' social and organisational context, and their existing work practices (e.g. Suchman, 1987; Button, 1992; Mackay, 1999).

The third wave expands the research of HCI from the workplace to various different sociocultural contexts, including everyday life and culture, while taking into account a wide range of application types and technologies (Bødker, 2006). Recognising interaction as situated *and* embodied action (Dourish, 2001; Klemmer et al., 2006), third-wave HCI investigates how to design interactive systems for specific sociocultural contexts. This includes how they can be adapted and are appropriated by their users, and how to support and evoke various subjective user experiences. Examples of third-wave HCI include designing for fun and play (Gaver, 2002; Nijholt, 2014) or to evoke specific emotional responses (e.g. Dey and de Guzman, 2006; Vidyarthi et al., 2012). Therefore, studying human-machine interaction is becoming more focused on examining socio-technical interactions and phenomena where “what goes on around systems is more interesting than what’s happening at the interface” (Harrison et al., 2006). Given the more open-ended questions and research objectives, HCI has increasingly adopted methods from the social sciences based on the collection and analysis of qualitative data. Typical examples are ethnographic methods such as contextual interviews, field observations, or video-based interaction analysis, often embedded in situated, contextual research. Recent HCI research draws on such approaches to develop a rich, descriptive understanding of technology-mediated interactions situated in various contexts and scenarios of everyday life.

4.2 Evaluation and Interactive Art

HCI’s recent focus on the subjective user experience, and the exploration of the creative, social and aesthetic dimensions of technology-mediated interaction, closely resonates with the objectives of interactive art, where the participant’s

experience is central to the work (see *Interactive Art*, pp. 27-28). In particular, there are synergies between HCI and interactive art research, which systematically investigates audience interaction and engagement with interactive artworks (Candy and Edmonds, 2011). While at first sight the technical similarities between HCI applications and interactive art systems may be the most obvious, there are also significant overlaps in terms of evaluation and related objectives. For example, Candy (2014) points out that “how to design a system for playful interaction where the users/participants are the general public is as much an HCI question as it is a digital arts one.” By adopting methods from HCI and adapting them to the art context, practice-based interactive art research considers evaluation as a key practice for improving the design of novel interactive art systems, and facilitating a broader understanding of the audience experience (Edmonds and Candy, 2010; Candy, 2011).

Conversely, besides drawing on HCI, interactive art research arguably can also contribute to HCI. Edmonds (2014) points out that insights made through art research informed by HCI and psychology, can feed back into HCI and lead to new ideas and perspectives. Typical examples are conceptual frameworks for interactive experiences that stem from art research, several of which were outlined earlier (see *Interactive Art*, pp. 27-28).

Since the approach to evaluation, as established in recent interactive art research (e.g. Candy and Ferguson, 2014), is closely aligned with the research objectives of this thesis as discussed earlier (see p. 30), it is used as a guide for developing the evaluation approach. Before mapping out the specific evaluation methodology for this thesis, a general framework is presented that aims to assist this process.

Based on her model of creativity and evaluation in the interactive digital arts (Candy, 2012), Candy (2014) proposes a general framework for evaluating interactive art development and experience. As illustrated in Figure 4.1, the framework identifies four main elements to be considered: *participants*, *experience*, *outcomes*, and *environment*. Candy (2014) further suggests that for each

Evaluation + Interactive Experience

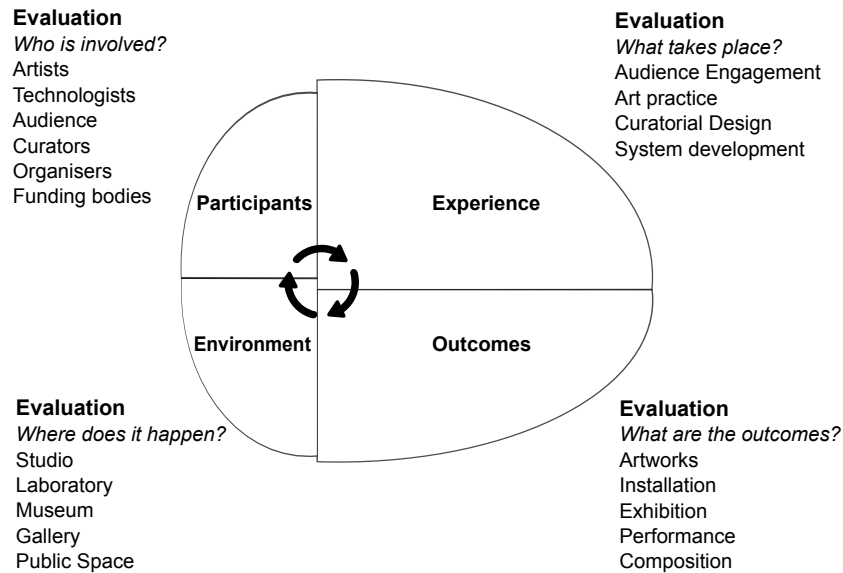


Figure 4.1: Evaluation and Interactive Experience Framework.
Adapted from Candy (2014) with permission.

of these basic elements, a number of *features* to be evaluated can be identified, and for each feature, specific *criteria* for evaluation can be defined. Table 4.1 lists a number of possible features and criteria for evaluation that can be associated to the four main elements. An example would be to evaluate whether an interactive system for the general public (element: participants) is capable of evoking the experience (feature) of curiosity (criterion). By providing a fine-grained structure for assessing the various dimensions of the scenario to be evaluated, the framework aims to guide researchers through identifying the specific requirements as basis for choosing appropriate evaluation methods. To illustrate how such an assessment can inform the choice of evaluation approach and methods, Candy (2014) refers to Study I (Chapter 5), as presented in Bengler and Bryan-Kinns (2014a), as exemplar for an ‘in vivo’ approach, and to ‘video-cued recall’ as a method for eliciting audience responses to experience. Video-cued recall (Costello et al., 2005) is briefly discussed in the next section.

Evaluation + experience	Actors	Features to be evaluated	Criteria for evaluation
Participants	Artists	Imagination	Levels or degree of:
	Technologists	Artistry	Motivation
	Audience	Expertise	Skill
	Curators	Skill	Education
	Organisers	Experience	Expertise
	Funding bodies	Intention	Engagement
		Reputation	Curiosity
		Success	Commitment
		Failure	Resources...
Experience	Audience engagement	Response	Positive
	Art practice	Behaviour	Negative
	Curatorial design	Attitudes	Opportunistic
	Art system	Risk taking	Adventurous
		Interaction	Curious
		Innovation	Cautions
		Design quality	Experienced
		Performance	Transcendent...
	Outcomes	Artworks	Novelty
Installation		Originality	Immediate
Exhibition		Impact	Engaging
Performance		Adaptability	Purposeful
Composition		Aesthetics	Enhancing
		Effectiveness	Exciting
		Appropriateness	Disturbing
		Physical space	Design quality
		Lighting	Convincing
Environment		Museum	Facilities
	Gallery	Costs	Effective
	Public space	Time	Innovative
		Resources	Sufficient
		Effort	Sustained
		Constrains	Damaging
		Support	Copious

Table 4.1: Actors, Features and Criteria for Evaluation.
Adapted from Candy (2014) with permission.

4.3 Evaluating Collaborative Musical Experiences

Based on the broader perspective of experience-focused evaluation, the specific frame for evaluation in this thesis is set out in the following sections. The first section discusses the decision to conduct all instances of evaluation in public, real-world settings. The second section points out the practical implications of this decision, and how contextual demands and specific evaluation objectives are incorporated into the adopted evaluation approach.

4.3.1 Why ‘In the Wild’?

The focus of this thesis is on collaborative, technology-mediated music-making for broad audiences in public settings. In terms of Candy’s (2014) evaluation framework, members of the general public are defined as *participants*, and museums, galleries and other public spaces are defined as the *environment*.

The decision to conduct all instances of evaluation ‘in the wild’ is motivated by the notion that the user’s experience of a technology is considerably influenced by the context of its use (Blomberg et al., 1991; Mackay and Fayard, 1997). Furthermore, as this thesis is not only interested in the technological aspects of user interactions, but most notably in the accompanying social dynamics, a contextual approach appears to be more appropriate. It is arguable also that the users’ social behaviour is significantly influenced by the context of their actions and that, removing them from the larger social context leads to change in their behaviour “in nontrivial ways” (Blomberg et al., 1991). Considering more recent HCI applications, Rogers et al. (2007) argue that laboratory studies of ubiquitous computing technologies are prone to omit important aspects that arise from their real-world context of use. For example, a contextual study of a multi-user tabletop information system by Marshall et al. (2011) demonstrated that situated characteristics of use differed from those previously identified in laboratory settings.

In general, this suggests that laboratory based approaches are of limited value when dealing with technology-mediated public creativity. Heath and vom Lehn (2008) point out the inadequacy of assessing interactive exhibits “without taking into account the contingencies that emerge in actual museum spaces.” For example, in a laboratory setup, the fact that participation is based entirely on people’s prior commitment rules out the possibility of realistically assessing engagement factors such as ‘attractors’ or ‘sustainers’ (Edmonds et al., 2006) as introduced earlier (p.27).

These considerations call for the use of ethnographically informed methods. As discussed earlier in this chapter, a common goal when examining such new forms

of socio-technical interaction, is to develop an understanding of how people behave and interact in these scenarios within a real-world context. Gathering qualitative data such as field notes, contextual interviews and video observations provides a rich data set, which then serves as a resource for developing a situational understanding through systematic analysis. Moreover, in contrast to laboratory based settings, the contextual approach enables the researcher to observe the interactions of large numbers of people. This allows for the possibility of detecting patterns of audience behaviour (Bilda, 2011). Furthermore, social practices can be identified “in and through which [these] patterns (like structures and processes) emerge” (Crabtree et al., 2000). In addition, this systematic approach allows for comparisons to similar studies and assessment of their general applicability, whilst leading to a deeper understanding of the studied interaction scenario. This then becomes a key resource for informing related work and future designs.

4.3.2 Incorporating Research Goals and Practical Demands

As pointed out by Alarcón-Díaz et al. (2014), the focus of an audience evaluation is also largely dependent on the particular aims and motivations of its conductors. This section illustrates how practical demands and the specific research objectives of this thesis are accounted for in the evaluation approach.

Woolrych et al. (2011) use the metaphor of ingredients and meals (rather than recipes) to illustrate how to appropriately develop evaluation approaches which address particular research questions, while incorporating given constraints and available resources. A similar view underlies the PRETAR framework (Purpose, Resources, Ethics, Techniques) by Blandford et al. (2008), which attempts to build on and extend the DECIDE framework as introduced by Preece et al. (2002). Both frameworks propose a systematic, structured and use-oriented approach to design evaluations for specific purposes.

In this thesis, the commitment to conduct all instances of evaluation in real-world settings is a decisive factor for developing the evaluation approach. An

implication of this decision is to give up some degree of control, in comparison to evaluation in a laboratory environment. In terms of a public museum, this means complying with aesthetic standards and practical demands and being responsive to institutional concerns and regulations. Examples include spatial constraints, restrictions in terms of system feedback (e.g. sound level) as well as issues related to ethics and health and safety. Moreover, it is important to keep in mind that from a curator's and visitor's perspective, the studied artefact is primarily considered as an exhibit while the researcher's interests might have no direct relevance to them. Therefore, it is important to consider carefully to what extent one wants to 'interfere with' these expectations when conducting contextual research.

The evaluation approach as used in this thesis was initially developed for conducting a two-day audience evaluation of *Polymetros* during an exhibition at the Victoria and Albert Museum (V&A), as reported in detail in Chapter 5. After approval from Queen Mary Research Ethics Committee, the V&A granted permission for handing out questionnaires, conducting interviews and making video recordings according to specified conditions. General contextual demands were: a limited overall time frame (two days, seven hours each); small allocated space; and restricted times for setup and dismantling.

In accordance with the research goals of this thesis (see p.17), the main objectives of the audience evaluation is twofold: first, to inform a general understanding of how people engage and interact with such a collaborative interactive experience in a public setting, and second, to assess the design in relation to its underlying rationale - in particular, to examine the effect of perceived control. Therefore, key *features* (Candy, 2014) to be evaluated were sense of control, sense of participation and enjoyment, and how they related to each other. The first research goal was addressed by adopting ethnographic practices as described in Section 4.3.1 above. The second objective, demanded a more direct approach in order to elicit specific responses in relation to the users' interaction with the system and their perceived experience. One method that was

considered for this task was video-cued recall (Costello et al., 2005), a technique used in interactive art research to elicit such experience-related responses, as briefly mentioned earlier (see p. 76). Video-cued recall involves playing back video recordings of participants’ live experience as soon as they have finished interacting, which they then comment on. This helps to elicit a moment-by-moment review of their experience. However, this was not feasible at the V&A (as well as at the locations of Study II and III) as no private room was available for conducting such a post-hoc procedure. For similar reasons, semi-structured interviews could not be conducted due to high visitor density, and lack of alternative private space. In addition, the study had to be integrated seamlessly into the exhibition’s routine operation which argued against employment of recruited participants.

Therefore, to examine the identified features, a self-report questionnaire was developed. The item and survey design is described in detail in the following section. In addition to this experience-focused questionnaire and the application of ethnographically informed methods, interactional data was collected. Users’ data input was recorded via a logging mechanism built into *Polymetros* to capture how they had used the instrument’s interface, and what kind of musical patterns they had created (see p. 70). This approach was motivated by the desire to complement interface-specific observations, examine interaction patterns, and gauge relatedness (or ‘unrelatedness’) between the users’ self-reported responses and their actual interaction with the system.

4.3.3 Description of Methods Used

While the previous two sections presented the general motivations for applying a study approach including questionnaires, video-based interaction analysis and user-system interaction data, this section provides detailed rationale and description of each of these methods.

Questionnaire

In accordance with the research objective to investigate the value of perceived control in collaborative musical experiences (p. 17), there was a particular interest in probing participants' perceived *sense of control* along with their *sense of participation and enjoyment*, and whether they are related to each other. Since, as mentioned earlier, other methods for eliciting these specific responses proved unsuitable due to local conditions (lack of private space, high visitor density, see p. 81), a questionnaire approach was chosen because it can be used to elicit responses from large numbers of participants (hundreds), whilst seamlessly integrating into a naturalistic study context with unsolicited audience members, providing as low interference as possible with their visiting experience as discussed earlier (p. 80). However, this also required a very limited number of questionnaire items to allow for a quick, 'on-the-spot' completion. Table 4.2 shows the final questionnaire as used in the three studies of this thesis. The following section provides a detailed description of the questionnaire design and how this built on previous self-report measures devised to probe interactive playing experiences.

Design: As an initial design step, three thematically related questionnaires were reviewed which focus on participants' experience of technology-mediated, collaborative music-making (Bryan-Kinns and Hamilton, 2009; Fencott and Bryan-Kinns, 2012; Bryan-Kinns, 2013). These included the relevant aspects of *perceived control*, *sense of collaboration* and *feeling of enjoyment*. Using these as initial guidelines, a list of potential questionnaire items was compiled. To improve the items' validity, all items were then revised in close consideration of the Game Experience Questionnaire (GEQ) (Poels et al., 2008), a validated self-report tool which was found to provide a significant thematic overlap with both the guideline questionnaires and the aspects of interests to be probed as specified above. The GEQ, which was developed as part of the EU-funded FUGA project

(Fun of Gaming)¹, is a comprehensive survey to probe participants' subjective experience of digital play and gaming experiences across several dimensions. These include perceived components of play such as competence, challenge or positive affect. The core GEQ is complemented by a social presence module (SPGQ) designed for multi-person and collaborative playing scenarios probing players' awareness and involvement with their co-players, both in virtual and co-located settings (de Kort et al., 2007). Where possible, the questionnaire items were adopted nearly verbatim from the GEQ/SPGQ (e.g. E2, E3, E4, E6). The items were then grouped according to the three main factors to be probed: 1) sense of participation and collaboration, 2) sense of control and perceived challenge, and 3) satisfaction with interaction and overall experience. To comply with the need for brevity, this list was reduced to the seven experience-related items as shown in Table 4.2. This number was mainly determined by the small form factor of the questionnaire (A5 format), which was deliberately chosen to convey a casual, flyer-like appearance, visually indicating a short completion time. In the selection process, priority was given to items which most directly addressed the research interest in participants' perceived sense of control and sense of participation and enjoyment.

E1: I felt part of a creative process.
E2: I felt in control.
E3: I felt connected to the other players.
E4: It was challenging.
E5: I liked the music we created.
E6: My playing was influenced by the playing of the others.
E7: I would recommend playing <i>Polymetros</i> to my friends.

Table 4.2: Core questionnaire items.

In this final listing, E1, E3 and E6 relate to sense of participation and collaboration, E2 and E4 to sense of control and perceived challenge, and E5 and E7 to satisfaction with interaction and overall experience. These items were rated by

¹FUGA: <http://fuga.aalto.fi/> (Retrieved July 1, 2015)

the participants on a 5-point Likert-type scale (not at all - slightly - moderately - fairly - very much). These core items were complemented by an introductory section eliciting demographics (age, gender) and additional participant information (e.g. self-rating of musical proficiency). While the experience-related core items remained unchanged in all three studies of this thesis to allow for overall comparability, the introductory section was adapted for each study in order to best elicit additional relevant participant information considering the studies' differences in context and audience (e.g. museum vs. music festival). These study-specific items will be reported in the corresponding sections of the three study chapters (see p. 96, 120, and 142).

Discussion: While the questionnaire was devised in close consideration of the validated GEQ/SPGQ, the main compromise that had to be made was the drastic reduction in questionnaire items to allow for seamless integration into the public study context as discussed earlier (very short completion time, unobtrusive appearance). As an illustration, the GEQ consists of a total of 59 statements to be rated (each factor is represented by six individual items), which can easily take at least 10-15 minutes to complete. This was considered impractically long for the chosen approach to elicit response data from unsolicited visitors. Due to time constraints in preparation for the first study of this thesis at the Victoria and Albert Museum (V&A) (see Chapter 5), an opportunity which arose at short notice, there was insufficient time to undertake a formal design procedures (e.g. reduction of the initial collection of items through factor analysis on a large sample of test questionnaires). However, it has to be pointed out that the analysis of all response data collected in this thesis (475 questionnaires in total) as presented in detail in Chapter 8 (p.167), indicates validity of the questionnaire's factor structure as most items probing the same factor inter-correlate at a significant level.

Video-based Interaction Analysis

In order to address the research goal to develop a descriptive understanding of how people interact with and around *Polymetros* in real-world settings (p. 17), a video-based analysis approach was chosen. This choice was motivated by the objective to study participants' interaction in natural, real-world settings, in line with the argument that, as discussed in detail earlier (p. 78), user behaviour and characteristics of technology use are significantly influenced by the context in which they occur. The method used was informed by Interaction Analysis (Jordan and Henderson, 1995), an analytical approach for analysing situated, practical human activities, with a particular focus on the use of artefacts and other material objects as part of people's actions. Therefore, Interaction Analysis is considered particularly suitable for investigating technologically mediated human interactions (Frolich, 1993), such as the use of interactive artefacts. Related work that has adopted Interaction Analysis practices is Xambó et al.'s (2013) study of multi-user interaction with a musical tabletop in a lab environment, and Steier et al.'s (2015) study of physical interaction with a multitouch table in a public gallery setting.

In keeping with other ethnographically informed approaches, Interaction Analysis rejects imposing pre-defined theories, analytical frameworks and instructed techniques (e.g. preconceived coding schemes) on the analysis. In contrast, Interaction Analysis is committed to iteratively developing analytic categories directly from and through the observational data during the analysis process, guided by a number of topical *foci*, as described later. Therefore, being a general analytical approach rather than a specific method, the following paragraph provides a detailed description of how Interaction Analysis practices were adopted in this thesis.

Analytic Focus and Structure: Jordan and Henderson (1995) point out that the structure of the analysis and the level of detail are depending on the researcher's analytical interest. In this thesis, the main purpose of the video-

based analysis was to get a general overview of how people use the interactive features of *Polymetros* in order to reflect about the design, and to identify the most prevalent patterns of audience participation likely to be engendered by the installation. Another important factor was the objective to analyse a representative number of interaction instances for each of the three studies in order to compare observations in different socio-cultural settings. Therefore, the transcription deliberately concentrated on providing a descriptive account of players' visible conduct with, and in relation to, the installation's multi-user interface, and how other participants were involved in this activity. This was guided by number of transcriptions conventions as described below. Compared to, for example, Heath et al.'s (2002) video-based study of a mixed-media installation using Conversation Analysis, this is indeed a more high-level approach, but it was found adequate for the purposes of this analysis to identify *trends* in interface-related conduct and investigate prevalent patterns of participation. Most importantly, this approach enabled the author (who had to work alone rather than in a team as usually common in Interaction Analysis, cf. Jordan and Henderson, 1995) to systematically assess a significant amount of collected video data per study (around 5 hours per study) in a consistent and principled way, which allowed for the development of statements about emerging interaction patterns from multiple sets of observations across the three different studies. In addition, the focus on visible conduct was necessary due to practical constraints of the setting (cf. Heath et al., 2010, p. 41), in particular due to the fact that the study environment was acoustically dominated by the installation designed to provide a balanced sound impression for each player (see pp. 63-64), which impeded reliable elicitation of verbal communication from the video-material. However, if possible, verbal statements were included in the transcript.

The transcription undertaken in this thesis was structured based on a number of conventions derived from Jordan and Henderson's (1995) proposed "foci of analysis" within video-based Interaction Analysis. Intentionally distinct from analytic categories or coding categories, foci for analysis refer to specific per-

spectives towards the collected material which have been repeatedly identified as relevant for guiding video-based Interaction Analysis (Jordan and Henderson, 1995).

In accordance with the devised transcription conventions, transcription and analysis of participant's playing activities were organised into units of coherent activity, mainly defined by *shifts in activity*, *shifts in attentional focus*, or major *changes in spatial alignment*. Shifts in activity relate to, for example, changes in players' interaction strategy, the use of a new instrument feature, or the start of bodily movement such as head-nodding or dancing. Shifts in attentional focus refer to situations where players observably change their focus, for example, by reorienting their attention from their instrument to a co-player's instrument. Major changes in spatial alignment refer to situations in which, for example, a player switches between different instruments, or a group of visitors realigns themselves around the installation. Within this general structure of units of coherent activity, a particular focus was placed on aspects of *coordination and cooperation among participants*, *repetitive aspects and variability* (e.g. what musical patterns appeared frequently and how they varied), and the *beginnings and endings* of participant's active conduct, relating to how participants approach the installation (e.g. whether they observe others before joining), and the circumstances under which they withdraw and leave.

- ⋮
- (5:40) P50 turns the dial slowly to its left end position (LP filter effect) and holds it for a moment (drums are entirely 'filtered' out). Then he releases the dial to 'bring the beat back' instantly. P50 'augments' this action with a dramatic 'retraction' gesture of his whole arm. P50 smiles and starts nodding his head to the beat.
- (5:50) P50 addresses P51, who took over instrument 2 (5:15) after returning to the booth, apparently to show him this effect. P51 looks up for a moment, but quickly focuses back on his instrument.
- (6:15) P50 repeats this 'filter effect' (and associated gesture) for several times while editing the pattern.
- ⋮

Figure 4.2: Excerpt of interaction transcript (1).

Figure 4.2 shows a short excerpt from an interaction transcript (Study III, Instance 28, Appendix C.5). The fragment’s first unit of coherent activity (timestamp: 5:40) is defined by a shift in activity, as the player (P50) starts a new type of action (turning the dial). The transcription gives a descriptive account of execution and style of interface manipulation, the related effect on music produced, and the participant’s expression and visible bodily activity. The second unit (5:50) is defined by a shift in P50’s attentional focus expressed by addressing a co-player, and describes the observable aspects of this mutual exchange. The following unit (6:15) considers repetitive aspects by describing the use of previously observed interaction patterns. As a second example, Figure 4.3 shows a transcription fragment (Study III, Instance 39, Appendix C.5) that is structured by units of active coordination and cooperation amongst participants (8:50, 9:10), and the circumstances under which a participant (F71) ends his active engagement with the installation (9:25).

⋮

(8:50) P71 addresses an observer standing close to him, a young woman who arrived a while ago (7:30), and offers her to explain the instrument (they apparently do not know each other).

(9:10) P71 deletes all notes from the grid. P71 demonstrates the instrument by setting a single note and successively building up a simple pattern.

(9:25) The woman nods, P71 takes a step back and she takes over the instrument.

⋮

Figure 4.3: Excerpt of video transcript (2).

The following paragraph describes how this approach was used to analyse video data collected in this thesis.

Practical Application: In each of the three studies undertaken in this thesis, this approach to analysis was applied to a number of pre-selected video instances (details on observational data are included in the study chapters). Each instance relates to an episode of active interaction with *Polymetros*, ei-

ther by one or several participants. For selecting material for analysis, a data corpus of approximately 5-6 h of video recordings per study was reviewed. In line with the objective to get a broad, general overview of people’s interaction with the installation, the selection was not based on a pre-evaluation of interactional content (e.g. whether it is “particularly rich” in conduct, cf. Steier et al., 2015), but mainly on participants’ visibility. This means that the primary criterion was selecting instances in which key participant(s) and related instruments were not occluded by other visitors, a demand that was not necessarily granted due to restricted options for camera placement and the high visitor density in all three studies (camera setup and local conditions are reported in detail in corresponding study chapters).

In all three studies the analysis was guided by the conventions as described previously, whilst transcription structure and representation were slightly refined throughout the thesis as follows. After the first study, where the video-based observations were transcribed as a running commentary, in subsequent studies, a structured format was applied where each unit of coherent activity was reported as a individual paragraph marked with a timestamp. The main reasons for adapting the transcription style were: 1) to provide better clarity and representation of exact temporal sequence of interactions, and 2) to allow easier highlighting of aspects of interest arising from the first study. For example, each instance was marked with whether or not *co-participation* took place, a phenomenon that emerged as a regular pattern of participation in the first study. In addition, each instance was labelled with its overall duration, the instrument(s) used, and if initial guidance by a research team member (facilitation) was provided.

In summary, informed by Interaction Analysis practices, the video-based study approach undertaken in this thesis was based on the analysis of selected video instances, structured into units of coherent activity defined by shifts in activity, attention, and spatial alignment, with a particular focus on cooperation amongst

players, repetition and variability of actions, and beginnings and endings of playing instances.

Interaction Data Analysis

Interaction Data Analysis was applied to complement questionnaire and Interaction Analysis approaches, using the data logging mechanism as described in detail earlier (p. 70). The analysis of user-system interaction data was motivated by the prospect to assess interface-specific observations through quantitative data analysis (e.g. whether they generalise to the majority of users), and gauge relatedness (or ‘unrelatedness’) between the users’ self-reported questionnaire responses and their actual interaction with the system. This approach follows Hornecker and Stifter (2006), who found that triangulating observational and interaction data can significantly inform the study of interactive exhibits and improve the validity of findings. Also Crabtree et al. (2012, p. 78) highlight the potential of system logs to provide additional insights into participants’ interactions when studying technology-mediated activities in the wild. In this thesis, the interaction data analysis is particular aligned with the video analysis’ focus on repetitive aspects and variability of players’ input strategies, allowing to test their generalisability across a large set of data to increase their validity (see *Input Strategies and Interaction Analysis*, pp. 104-108).

4.4 Summary

This chapter has presented an overview of experience-focused evaluation in HCI and interactive arts research, outlined synergies and relevance to the research objectives of this thesis, and provided a detailed account of the decision-making process that led to the applied evaluation strategy. Considering the specific research goals, contextual demands and related implications resulted in a mixed-method approach that combined questionnaires, field notes, video-based analysis and user-system interaction data. In the following chapters, this evaluation

approach is adopted to study the audience interactions with *Polymetros* in three contextual studies (Chapter 5, 6, and 7). Chapter 8.4 then provides a detailed assessment and discussion of the applied evaluation strategy.

Chapter 5

Study I: Victoria and Albert Museum, London

The first study took place at the Victoria and Albert Museum (V&A), London, UK, which is considered one of the world's greatest museums of decorative art and design¹. It was conducted during a two-day exhibition of *Polymetros* at the Digital Design Weekend 2012. As the first major study of this thesis, particular attention was paid to establishing the methods and their practical application in order to address the methodological considerations as discussed in Chapter 4. The applied evaluation approach also provides the methodological framework for the two subsequent studies and is adapted and progressively developed throughout this thesis.

5.1 Pilot Study

Before the first main audience evaluation at the V&A, a pilot study was carried out. It was conducted in order to initially evaluate options and feasibility of data collection mechanisms, whilst indicating aspects of the users' interaction to be considered and addressed in the main studies.

¹V&A website: <http://www.vam.ac.uk/> (Retrieved December 23, 2014)

The pilot study was conducted during an open studio event at Queen Mary University of London, which was part of the Digital Shoreditch Festival 2012. Addressing a public audience, this three-day event was based around artworks and scientific projects that incorporate interactive media technologies arranged as a hands-on exhibition. The *Polymetros* system was set up in an area of 5 meters by 5 meters in a darkened, multi-purpose performance space with low noise level. The location was shared with another interactive work which did not incorporate sound. During the exhibition 300 people played the first fully functional prototype of *Polymetros*. The system was observed over the entire 3 days of the event and descriptive field notes were taken. User interaction was video recorded from two different camera angles.

First-hand experience gained from the pilot, conducted in a public setting, significantly informed the study design. It allowed for a critical assessment of methodologies, addressing the complex demands of evaluating interactivity within a public context as discussed in Chapter 4. In addition, the pilot was used to test the system’s hardware and software components in a realistic scenario during long-term operation, which led to technical improvements that increased the overall system reliability and informed the final user interface design. During the pilot study, an initial version of the interaction data logging system was tested and then refined and extended for the audience evaluation in the V&A. Due to frequent user requests for individual tempo control, the function to switch each instrument’s playback tempo to ‘half-time’ was implemented subsequently.

5.2 Context and Study Setting

Study I took place on the 22nd and 23rd September 2012 at the Digital Design Weekend 2012 held at the V&A, London. Being part of the London Design Festival, this annual event is dedicated to digital art and design, including interactive installations, performances, demonstrations and workshops. The event was or-

ganised by V&A’s Digital Programmes team, which aims to engage visitors of all ages in a wide range of activities and events promoting digital and interactive art and design, and to stimulate audience participation and discussion and exchange among visitors, artists and creative industries professionals. Incorporating an open studio-like atmosphere, most of the exhibiting artists attended the event in order to demonstrate and discuss their work with the audience. The audience attendance was monitored by the V&A and conducted by members of staff individually for all venues associated with the event. A monitoring form was sent out to all exhibitors afterwards. The space where *Polymetros* was exhibited (V&A Digital Studio) received 1154 visitors on Saturday and 786 on Sunday.

5.3 Setup

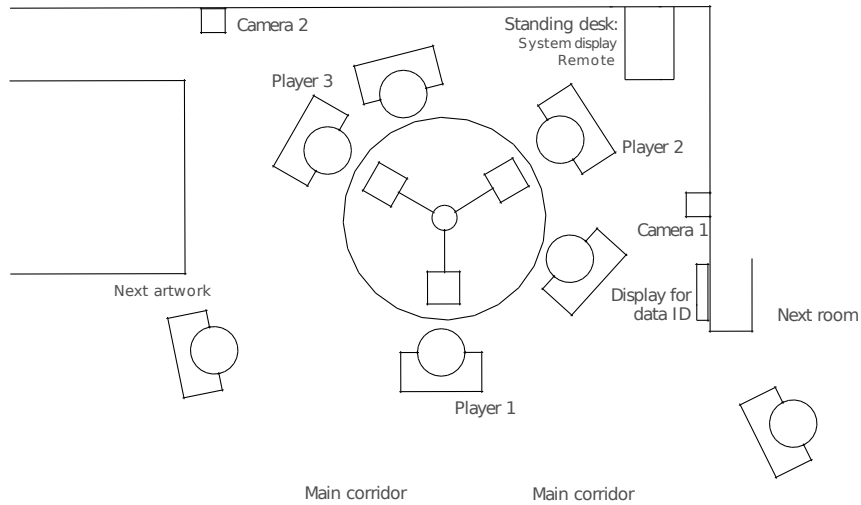


Figure 5.1: Study setup in the V&A

Polymetros was installed in a slightly darkened studio space alongside several other interactive and static artworks that required dimmed lighting. The available space was restricted to an area of 3 by 3 metres. The system was positioned

in such a way as to be approachable from all sides (Figure 5.1). Even though it was the only exhibit that incorporated sound in its immediate vicinity, the overall noise level was high due to the event’s open studio character. On request of the curator, the originally intended output volume had to be lowered to ensure that the sound was not audible in adjacent areas. User interaction was video recorded from two different angles.

The study was conducted with the help of two assistants. This enabled the author to focus on contextual observation and note taking whilst monitoring the system execution. The collaborators conducted and coordinated data collection as described in the following section and provided visitors with some initial guidance. Due to the open studio character of the event, the research team was also available to answer specific questions and discuss the exhibit with interested audience members.

5.4 Data Collection

Informed by the pilot study and the review and discussion of appropriate methods as described in Chapter 4, a mixed-method approach was applied combining questionnaires, interaction logs, field observation and video analysis.

5.4.1 Experience Questionnaire

As described in detail earlier (pp. 82-84), the questionnaire was designed to probe participants’ self-rating of different aspects of their playing experience. It was handed out by a member of the research team immediately after visitors finished playing; the forms were also available on a pedestal and a number of questionnaires were filled in on visitors’ own initiative. The questionnaire was designed to be completed in a short amount of time (1-3min) and was printed on A5 format paper. As mentioned earlier (p.83), this small form factor was deliberately chosen to convey a casual, flyer-like appearance, visually indicating a short completion time. Larger formats and the use of clip-boards were

avoided in case these might discourage visitors from approaching. The questionnaire was composed of 9 Likert-type items to be rated on a 5-point scale. The questionnaire items are listed in Table 5.1 The qualifiers of the response categories were:

not at all - slightly - moderately - fairly - very much

For the sake of clarity these qualifiers were repeatedly stated below the corresponding tick boxes for each individual questionnaire item. In addition, the participants were asked to indicate their age and gender. The back of the questionnaire gave a brief explanation of the research project and its objectives, as well as a statement relating to the confidentiality of the collected data. The respondents were asked to give written consent to the processing of the data for the purposes of this study. The original form is included in Appendix A.1.

S1: I am a musical person.
S2: I am experienced using interactive devices. (e.g. smart phone, tablet, video gaming)
E1: I felt part of a creative process.
E2: I felt in control.
E3: I felt connected to the other players.
E4: It was challenging.
E5: I liked the music we created.
E6: My playing was influenced by the playing of the others.
E7: I would recommend playing <i>Polymetros</i> to my friends.

Table 5.1: Questionnaire items Study I

The first two statements asked the respondents to rate their musicality and experience with interactive technology (S1, S2). In combination with the collected demographic information, these statements were designed as descriptive attributes for the group studied, indicating their task-related abilities.

The following seven items relate to how the participants *perceived* their actual playing experience. As described in detail in Chapter 4 (pp. 82-84), the statements were designed to gauge three main aspects: 1) the sense of participation

and collaboration (E1, E3, E6), 2) the sense of control and perceived challenge (E2, E4), and 3) the satisfaction with interaction and overall experience (E5, E7). .

5.4.2 Data Logging

One member of the research team was in charge of controlling the data logging mechanism via the MIDI remote as described earlier (pp. 70-71). For each individual data log, a numeric, unique ID was created. The two most recent ID codes for each instrument were displayed on a 19-inch monitor, colour-coded according to the related instrument. The monitor was placed near the side wall, clearly visible for all members of the research team. This allowed the assistant handing out the questionnaires to mark collected surveys with the corresponding ID, if a log file had been created for this particular user. Matching the collected questionnaires with the recorded user-system interaction data via the ID display demanded a high degree of attention and coordination from the executing research assistants. Due to the crowded setting and frequent rapid changeovers of players, the assistant controlling the data logging was not able to monitor and log all participants joining in and leaving the installation. In total, 63 of the 150 questionnaires could be collated to their corresponding interaction data. At the beginning of data analysis questionnaire responses from the matched data set ($n = 63$) were compared to responses from the full data set ($n = 150$). As the matched subset showed similar distributions and identical medians for all items, it was considered a representative sample and so no differentiation was made between the data sets when reporting the findings.

5.4.3 Observational Data

Direct observations were carried out for several hours on both days of the exhibition by the author. They were mainly conducted from a small standing table located in the corner of the room which was also used to monitor the system functionality via a nearby computer display. Field notes were taken based on

the observations of how people interacted with the installation and each other. The close proximity to the users also allowed for noting down verbal statements including spontaneous outbursts of players, communication between audience members and comments made to the research team. In addition, sketches were made to document frequently observed musical patterns. After the study, the handwritten notes were transcribed and compiled into a report and classified into 1) player actions, 2) general remarks, and 3) verbal responses (see Appendix A.2).

In order to complement the field notes and examine specific aspects in greater detail, five hours of the recorded video material were examined and 30 individual instances were selected for analysis. Each instance relates to an episode of active interaction, either by one or several participants, chosen mainly based on visibility (no occlusion of interface or participant(s) throughout the fragment). The selected instances were transcribed as a running commentary, guided by the devised analysis conventions as described in detail in Chapter 4 (pp. 85-88). The transcripts can be found in Appendix A.3. In contrast to the field observations, the analysis of the video recordings enabled more focused and detailed observations of how participants used their instrument's interface and what kind of musical contributions they created.

In summary, the main goal of field and video observation in this study was to get an initial overview of common and reoccurring interaction phenomena and inform analysis of the recorded interaction data.

5.5 Study Results

The following section presents the findings of audience evaluation, gained from analysing the different types of collected data. The questionnaire responses were analysed and represented using descriptive statistics. System-related and social interactions with and around *Polymetros* were based on the observational findings from analysing field notes and video data, as described in the previous

section. For analysing user-system interaction data a pattern recognition tool was devised, informed by observed playing and input strategies.

5.5.1 Questionnaire Analysis

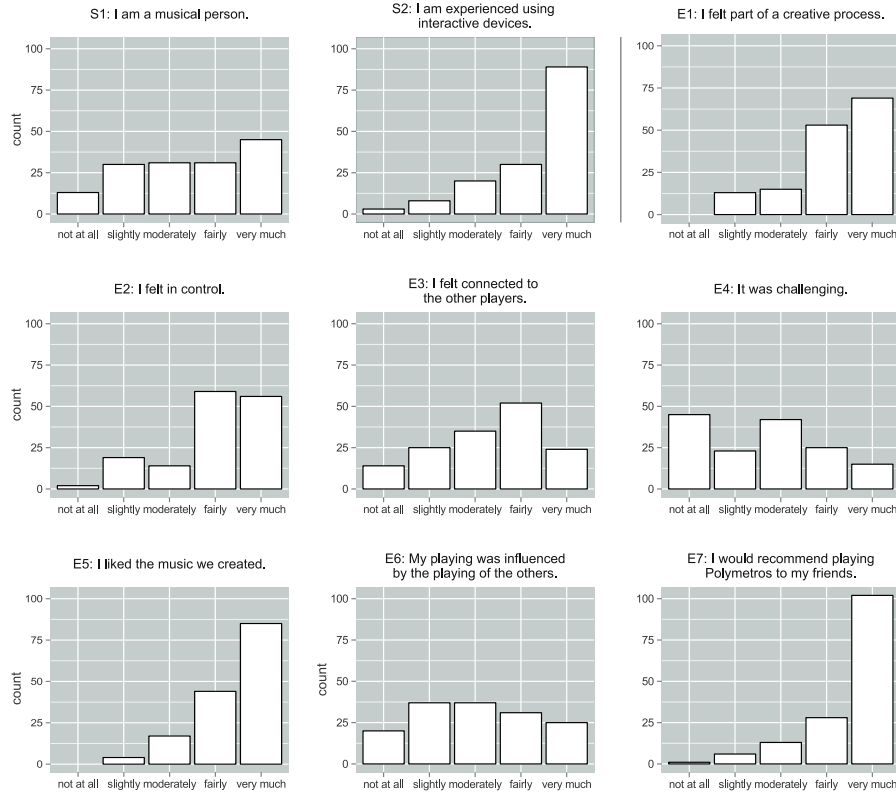


Figure 5.2: Questionnaire results Study I ($n = 150$). All survey items represented as individual bar graphs showing the frequencies for each response category.

During the two days of the exhibition the questionnaire was filled in by 150 participants (82 female and 68 male) from ages 5 to 66 ($M = 24.3$, $SD = 14.1$). The age range corresponded closely to the event’s visitor profile evaluated by the V&A indicating 67% of the audience in the 16-34 year group ($n = 67$) (Bentley, 2013).

Data of the questionnaire is shown in Figure 5.2. Each survey item is represented as individual bar graph showing the frequencies for each response category. All

bar graphs are uniformly normalised to the highest occurring frequency.

While the self-rating of the participants' musical abilities is distributed over a wide range (S1), the majority of them considered themselves to be experienced users of interactive technology (S2).

Visual inspection of the experience-related items shows that most participants evaluated their playing experience as very positive. 102 of 150 respondents stated they would *very much* recommend playing to their friends (E7, top box score 68%). In addition, the majority of participants indicated that they were pleased with the musical result (E5, top-two box score 86%). The high rating for feeling part of a creative process (E1) along with the relatively high rank for feeling connected to the other players (E3, median = *fairly*) suggests a commonly experienced sense of shared creative participation. The perceived challenge (E4) shows the greatest diversity in terms of responses with an interquartile range from *not at all* to *fairly* with a central tendency at *moderately*. This indicates that the majority considered the system's demands to be manageable. High ratings referring to the players' feeling of control (E2) indicate that the majority of users perceived a strong sense of personal control when interacting with *Polymetros*.

Bivariate Analysis

In order to address the research goal of investigating the value of perceived control in collaborative musical experiences (p. 18), bivariate analysis of the survey data was undertaken. The main objective of applying bivariate analysis was to examine tendencies of association between questionnaire items, in particular with regard to perceived control (E2).

Measure and Interpretation: Before presentation of the results, the selected measure of association *gamma* and its interpretation will be introduced. The same measure will be also used in subsequent studies (Study II, see Chapter 6 and Study III, see Chapter 7). *Gamma* is a non-parametric measure of

bivariate relationships between ordinal data (Sheskin, 1997, p.653), which is appropriate if both variables have only few categories (de Vaus, 2002, p.293). Similar to other correlation coefficients, such as Pearson's r for interval data, *gamma* ranges from -1 (perfect negative correlation) to 1 (perfect positive correlation). A value of zero implies the absence of association. *Gamma* allows for a PRE (Proportional Reduction in Error) interpretation (Costner, 1965). Therefore, the coefficient can be interpreted as the percentage of improvement in predicting correct values of one variable based on another variable. In survey analysis, the PRE-based correlation coefficient of two survey items indicates how much better a person's rating of one of the items can be predicted, given the knowledge of the other (de Vaus, 2002, p.257). A common frame of reference for interpreting the strength of a relationship in behavioural and social science research is based on the effect size thresholds proposed by Cohen (1988, p.79-80). Although initially derived for Pearson's r , they are commonly used as reference for interpreting strength of relationship coefficients in general, including *gamma* (e.g. de Vaus, 2002, p. 259). The usual interpretation is that correlations smaller than 0.1 are trivial, 0.1-0.3 are weak, 0.3-0.5 are moderate, and greater than 0.5 are strong. A detailed rationale for the choice of *gamma*, based on the characteristics of the study data, is provided in Appendix D.

	S1:	S2:	E1:	E2:	E3:	E4:	E5:	E6:	E7:
S1: Musicality	-								
S2: Tech. exp.	0.141	-							
E1: Process	0.104	0.065	-						
E2: Control	0.163	0.224	0.563***	-					
E3: Connection	0.049	-0.038	[0.504***]	0.428***	-				
E4: Challenge	-0.199	0.043	-0.056	-0.226	0.073	-			
E5: Like	0.211	-0.121	0.345*	0.335*	0.204	0.166	-		
E6: Influence	-0.009	0.063	[0.351**]	0.001	[0.509***]	0.376***	0.232	-	
E7: Recommend	0.248	0.111	0.414*	0.502***	0.270	0.172	[0.566***]	0.345*	-

*** Significant at the 0.0001 level (2-tailed)

** Significant at the 0.001 level (2-tailed)

* Significant at the 0.01 level (2-tailed)

Table 5.2: Correlation matrix Study I (n = 150). *Gamma* coefficients between all questionnaire items.

Results: Table 5.2 shows the correlation matrix of all questionnaire items. Before focusing on the aspect of perceived control, a general remark is in order.

Although visual inspection of the correlation matrix shows a fair number of significant associations, only a reduced set of them is considered relevant for analysis, as the seven experience-related questionnaire statements were designed to gauge three main aspects as described earlier (p. 96). Therefore, correlations between items that probe the same aspect are omitted. These are marked by square brackets. One example is the highly significant association between the items E1 ('process') and E3 ('connection') which were both designed to probe participants' sense of participation.

When focusing on perceived control (E2), the data revealed highly significant associations between 'feeling in control' and 'feeling part of a creative process' (E2/E1, $\gamma = 0.56$, $p < 0.0001$), 'feeling in control' and 'recommend playing to friends' (E2/E7, $\gamma = 0.50$, $p < 0.0001$), 'feeling in control' and 'feeling connected to other players' (E2/E3, $\gamma = 0.43$, $p < 0.0001$) and 'feeling in control' and 'like the created music' (E2/E5, $\gamma = 0.34$, $p < 0.01$).

These findings imply that experiencing control is related to other perceived qualities of the participants' experience. This supports the argument identified in the literature review that the perception of personal control is associated with the enjoyment and the feeling of being part of a creative musical process (see *What's My Sound?*, pp. 50-52).

Other significant correlations will be considered in Chapter 8, which presents and discusses the overall tendencies of association between questionnaire items across all three studies.

In summary, the questionnaire analysis suggests a commonly experienced sense of creative participation and enjoyment among the participants, and indicates an association between players' sense of control and other perceived qualities of their playing experience.

5.5.2 System Interactions

Over the two-day period of the exhibition, *Polymetros* demonstrated strong audience appeal. Most of the time all three instruments were in use, and the

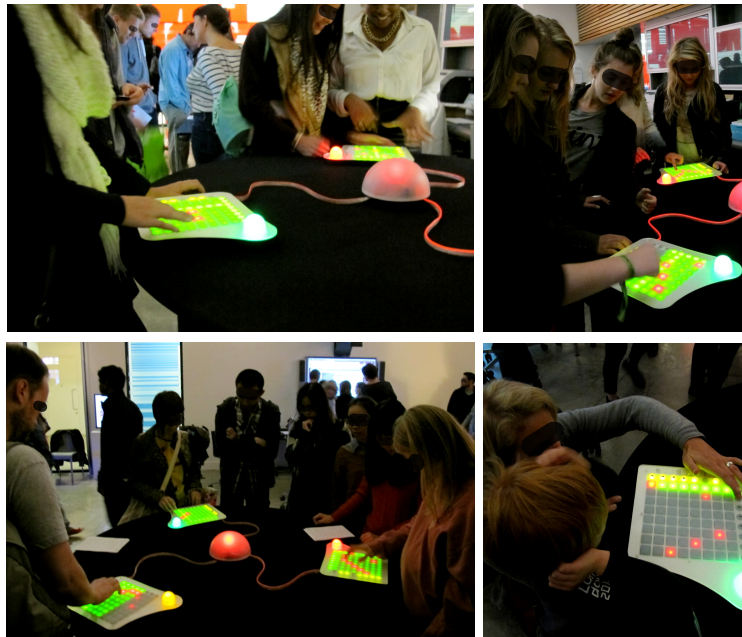


Figure 5.3: Polymetros at the V&A

players were usually surrounded by a number of spectators. This situation established an area of interest that attracted passing visitors to take a closer look at *Polymetros*, the majority of whom stayed to interact with it. Brignull and Rogers (2003) reported a similar social dynamic in relation to public interactives referred to as the ‘honey pot effect’.

Interface Interaction

In a crowded setting, people appeared to learn how to use the instruments by watching previous players. Several audience members were observed performing well-directed actions immediately after they took over one of the instruments, showing a prior understanding of the interface. Only complementary features such as loop length or tempo selection had to be explained by the facilitator. Generally, it was found that the majority of visitors understood the interaction concept after brief guidance by the facilitator. However, due to the rush of people over sustained periods, it was not possible to provide initial guidance to

all newly arrived players. While many visitors were able to discover the relevant aspects of their instrument on their own, a number of audience members could be observed having difficulties in understanding the interface. This seemed to be mainly related to a lack of understanding of the interface’s loop-based concept, as suggested by observations of inappropriate input gestures in relation to the sequential playback of the instruments grid.

In general, however, the physical interface successfully promoted understandability for both the surrounding audience and the players. This is in contrast to screen-based multi-user exhibits, which have been criticised for excluding the surrounding audience from understanding interaction with the system by undermining “mutual and public visibility of conduct” (Heath et al., 2002). The physical LED-based interface provided a highly visible representation of interaction which allowed spectators to observe the players, whilst giving the participants visual access to their co-player’s actions.

A key experience for many participants appeared to be the moment of realisation of ‘how it works’, which could be observed when a hint given by the facilitator or a co-participant led to an understanding of the instrument’s functionality. Accompanied by a sudden recognition of their instrument’s ‘voice’ in the overall music, many participants reacted to this understanding with a facial expression of excitement or spontaneous outbursts. This particular moment of insight or the ‘aha moment’ (cf. Csikszentmihalyi, 1996) could also be described as the ‘This is me!’ experience, since this phrase (or synonymical expression) was exclaimed by several participants when recognising *their* pattern in the overall music.

Input Strategies and Data Analysis

An input strategy that was widely observed was the creation of musical patterns characterised by simple geometric properties. The most common ‘phrases’ consisted of horizontal and upward or downward diagonal ‘lines’, which used in most cases all available notes (Figure 5.4). These are referred to as ‘closed mu-

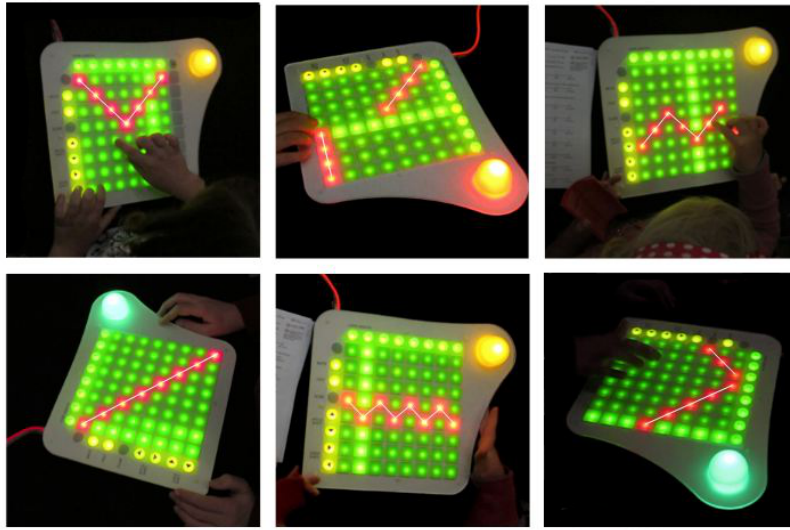


Figure 5.4: Typical musical contributions

sical figures' (see detailed description below). This approach was observed as used by large numbers of players during the study. Initiated by these observations, a data analysis tool was devised to examine how this observed interaction strategy generalises across all recorded instances of playing ($n = 294$).

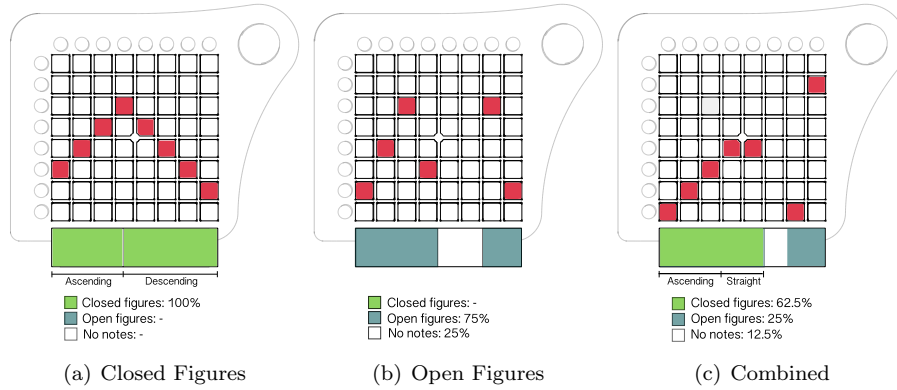


Figure 5.5: Illustration of the retrieved pattern categories

In order to retrieve the observed structural properties from the collected data set, a pattern recognition approach was applied. As described earlier (p. 71), recorded input data was pre-processed and segmented into subsets, each corresponding to a single playing instance. Via a bespoke software tool, these subsets were then analysed and visualised as illustrated in Figure 5.6. Based on the observations, ‘closed musical figures’ were defined as sequences of successive notes that either have the same pitch or the next higher or lower pitch in the chosen scale (pitch distance of one scale step) (Figure 5.5(a)). Additionally, the analysis indicates the progression of the ‘closed figure’ (descending, straight, or ascending). The other categories of pattern recognition were ‘open figures’ and ‘no notes’. ‘Open figures’ refers to sequences of successive notes with a pitch distance larger than one scale step (Figure 5.5(b)). ‘No notes’ relates to rests in a musical figure or longer periods without notes. The colour-coded bars and associated percentages below the three exemplar patterns in Figure 5.5 demonstrate their classification and visualisation during analysis.

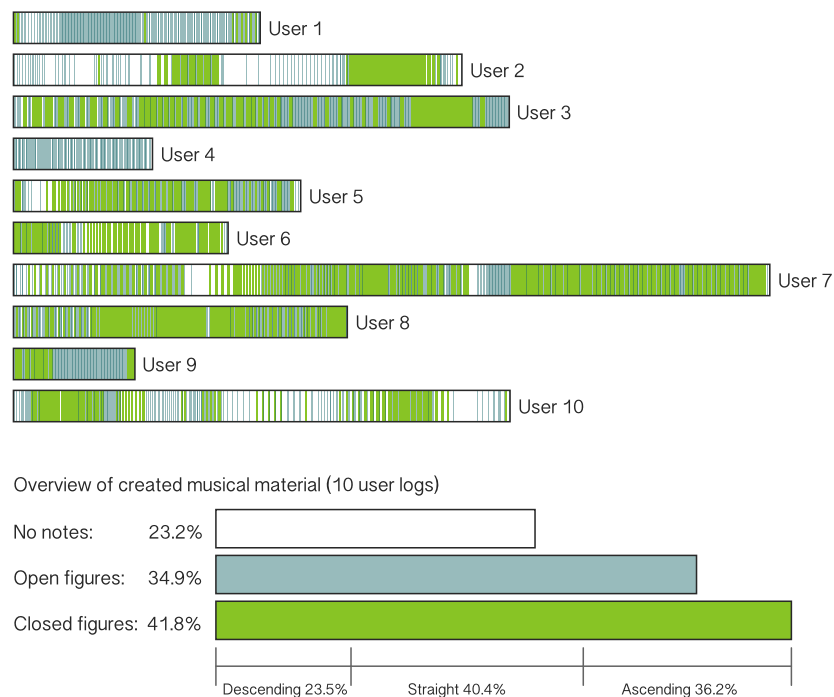


Figure 5.6: Data analysis tool: Pattern recognition and visualisation for a subset of instances of playing ($n = 10$).

Figure 5.6 shows an example of the analysis tool's outcome when applied to interaction data from a random selection of ten participants. Each playing instance is visualised over time as a colour-coded bar according to the categories defined above. The bar graphs show the percentage of occurrence of each category across the selected ten playing instances.

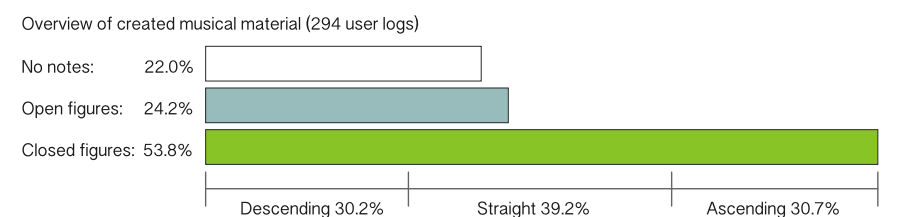


Figure 5.7: Percentages of occurrence of each pattern category across all recorded instances of playing ($n = 294$).

The tool was used to analyse all gathered interaction data. Figure 5.7 shows

the summative overview for all playing instances that were recorded during the study ($n = 294$). The analysis shows that 54% of the musical contributions were organised according to the properties of closed musical figures. This confirms the general observation, demonstrating that the identified, prevalent tendency towards closed musical figures generalises across all recorded playing data for Study I.

In general, it appeared that the players' overall preference for closed musical figures was related to the fact that for many people such figures were easier to identify within the overall musical outcome, compared to more 'sparse' or complex patterns. Often such phrases were modified in an incremental manner by changing just a single event per playback cycle. This strategy suggests a systematic attempt to create distinct alterations that provide clear auditive feedback in order to develop their understanding of the interface.

Initiated by these observations, the matched data set ($n = 63$) was used to examine if this clearly organised interaction strategy of closed figures related to the participants' perceived level of control during their playing experience. This was undertaken by calculating Kendall's *tau* correlation coefficient. *Tau* was chosen due to its adequacy to measure association between ordinal variables with few categories (5-point scale) and interval variables with many categories (percentage of closed figures) (de Vaus, 2002, p. 294). There was a significant correlation ($\tau = 0.20$, $p < 0.05$) between the players' reported level of control and the extent to which they organised their contributions as closed figures. Along with the findings from direct and video observations as presented above, this indicates a mutual relationship between this particular interaction strategy and the players' experience of control.

A more specific observation relating to these closed musical figures is that they appeared to have an important role for explaining 'how it works'. In various examples, audience members were observed using this input strategy to explain *Polymetros*' functional principle to their co-participants. Having created a simple closed figure, such as a sequence of consecutive notes in ascending order being



Figure 5.8: Participant explains instrument to companion.

played back continuously, they illustrated the instrument’s musical output by pointing their finger at the note currently sounding on the grid. In this way, they ‘augmented’ the instrument’s visual feedback, which already indicated the currently sounding note via a horizontal light bar ‘travelling’ over the grid in time with the music. By making the audio-visual relationship between a pattern’s representation on the interface and its musical result as clear as possible (e.g. ascending ‘line’ leads to ascending melody), this strategy appeared to be the most common and successful way to communicate the functionality and underlying concept to others. In addition, several audience members supported this demonstration by humming along with the pattern played. The social configuration in such instructive demonstrations often resembled an explicit ‘teacher-apprentice’ relationship as observed by Peltonen et al. (2008) around public touch displays, as reviewed earlier (see pp. 30-34).

Figure 5.8 shows an example. Having not yet understood the loop-based concept of the instrument, a man (P1) is instructed by his companion (P2). At first,

P2 resets the grid (frame 1) and creates a typical closed musical figure (frame 2). Then he rhythmically points at every played note following the pattern for several playback cycles (frame 3, 4). After signalling his understanding (exclamation: “ah!”), P1 points along with the pattern (frame 5) before turning to P2 who acknowledges his understanding with a nod.

In this way, participants appeared to externalise their understanding of the system in a natural way, providing valuable information about how to facilitate the playing experience in an effective way. In subsequent presentations of *Poly-metros*, the explanation strategy observed, based on a simple closed musical figure, was adopted by the facilitator for delivering short initial guidance to new players.

Another social role identified was ‘ambassador’; participants who, without being asked to do so, took on a similar role to the facilitator and explained the instruments to others. These were typically people who were very exited about the installation and ‘stuck around’ for well beyond the average dwell time. A similar phenomenon, called ‘emergent champions’, is described by Akpan et al. (2013) based on observations around public, interactive wall displays.

Observed Difficulties

In several cases, the similar sound characteristics of the different instruments appeared to cause difficulties for players in identifying their pattern in the overall musical output. As described earlier (p.67), due to their versatile sound characteristics, either mallet or pitched percussion-based sounds were used for all instruments, and players were able to shift their phrase over a range of six octaves. But as a consequence, the instruments sounded quite similar when played in the same octave register. While this finding suggests that it may be better to use more distinctive sounds, restricted to certain pitch ranges, this would come at some cost, as it appeared that many players particularly enjoyed ‘shifting around’ their phrase over a wide octave range in a dynamic manner, providing immediate and salient acoustic feedback. As a compromise, in the

first design iteration (see Table 3.1), the number of available octave registers per instrument was restricted from six to three. The instruments’ octave ranges were staggered from low to high with only one octave overlap between two instruments respectively.

5.5.3 Social Interactions

Forms of Participation

Despite the fact that the interaction with *Polymetros* appeared to be appealing and very enjoyable for participants, it should be noted that collaborations involving *active engagement* between ‘instrumentalists’ was not frequently observed during the reported study. Active engagement refers to situations where players seek to influence each other’s playing or coordinate their efforts in systematic ways, e.g. to collaboratively develop the musical outcome over a period of time. However, several occasions were observed where players commented on their actions or discussed their playing activities across the table. In all of these cases, the participants appeared to know each other as friends, couples or family members. In addition, playing techniques such as muting an instrument rhythmically, in relation to another pattern, was observed several times during the study. This showed an explicit awareness of other players’ contributions. However, unlike in the pilot study, where several groups of players actively ‘performed’ together, such occasions were not observed during this case study.

Reviewing video footage of the pilot, actively coordinated collaborations mainly took place if audience members who were already acquainted approached *Polymetros* whilst it was not in use. In such cases, it could be observed that groups split up to play on different instruments, explored the system together and developed strategies to coordinate their actions via verbal and non-verbal communication. In addition, this approach seemed to promote mutual awareness and interest in co-players’ actions. However, due to the high visitor turnout at

the V&A, new players usually joined in an ongoing musical process as individuals, rather than exploring the system together in a group. Not knowing other players appeared to be the main barrier to actively engaging with them in order to jointly coordinate the musical outcome.

Reflecting on these findings, from a visitor's perspective, *active collaboration* might not be a necessarily relevant or desirable aspect in the context of such a highly-frequented, public setting. However, it is interesting to note that, despite the limited degree of active engagement observed between different 'instrumentalists', half of the respondents stated in the questionnaire that they *felt* either fairly (35%) or very much (16%) connected to the other players. This indicates that many audience members experienced their playing as a joint activity even though they did not directly communicate with other players.

It was very common for familiar audience members such as friends, family members or couples to decide to play together on a single instrument when approaching *Polymetros*. Facilitated by the interface's physical and tactile properties, they explored their instrument together by explaining the interface to their companions, co-editing a musical pattern or commenting on each other's actions. These observations correspond to the findings of vom Lehn et al. (2001) that interactive exhibits are often examined by visitors in interaction with their companions. Such commonly observed co-participations on a shared instrument appeared to be a highly social and collaborative activity in itself.

Dwell Time in Context

Another aspect of interest was to examine the factors influencing how long audience members actively engaged with the system. In the context of museum evaluations, this time period is often referred to as *dwell time*. In this thesis, dwell time is defined as the duration a participant was actively interacting with one of the instruments. Based on 294 interaction logs, the average dwell time was 3.3 minutes (SD = 2.8).

Using the matched data set ($n = 64$) as described earlier (p. 97), the relationship

between the participants' dwell times and their questionnaire responses was explored by calculating the Kendall's *tau* correlation coefficient. *Tau* was chosen due to its adequacy to measure association between ordinal variables with few categories (5-point scale) and interval variables with many categories (dwell time in seconds) (de Vaus, 2002, p. 294). Taking into account the items 'process' (E1), 'control' (E2), 'like' (E5) and 'satisfaction' (E7) there was no association between the respondents' dwell time and how they rated such aspects in the experience questionnaire. Therefore, the video footage was analysed for evidence of factors affecting dwell time.

The video observations indicated that the players' dwell time was considerably influenced by high visitor turnout during the study. It appeared that people were likely to quit playing and leave their instrument if they became aware that another audience member was waiting in their direct vicinity. In such a situation many audience members seemed to feel an *obligation to leave* in order to make room for other visitors. This was supported by the fact that the average dwell time of 3.3 min ($n = 294$) approximately corresponded to the dwell time measured on the opening evening of the pilot study, where the system was similarly highly frequented (3.8 min, $n = 92$). On the two following days of the pilot, which were much less well-attended, the average dwell time increased to 5.9 min ($n = 72$). It was also observed that several visitors appeared to quit playing merely because their companions were moving on. These findings suggest that the participants' dwell time was likely to be determined by contextual and social factors rather than their individual playing experience.

5.6 Reflective Summary

This chapter set out to address the main research goals of this thesis; to develop a descriptive understanding of collaborative musical experiences in public settings, and to examine the value of perceived control in collaborative musical experiences. These objectives are central to all three studies of this thesis,

which investigates them in three different public contexts. Overall analysis and discussion, incorporating the results of all three studies, is provided in a dedicated chapter (Chapter 8) along with implications for design, and an overall assessment of the mixed-method evaluation applied, based on the findings and experience gained throughout the whole research process.

Social and Contextual Aspects: In general, Study I highlights the significant influence of the public exhibition setting on the participants' interaction, both with the system and with other members of the audience. Before becoming active participants, audience members were commonly engaged with the installation by observing active players, often forming an initial understanding through vicarious learning (cf. Brignull and Rogers, 2003). During participation, a common social configuration was co-participation, where acquainted audience members, most commonly pairs, took part by sharing one instrument. Active engagement between strangers was rarely observed and active interactions amongst players at different instruments mainly occurred between participants who knew each other. However, the observations indicated tacit mutual awareness amongst participants, and at least half of the respondents indicated a perceived connection to other players via high ratings of the corresponding questionnaire item. The triangulation of dwell time measurements, questionnaire responses and observations showed that the participants' dwell time was likely to be determined by social and contextual factors rather than being directly related to how they evaluated their playing experience.

Interactional Aspects: Through direct and video observations, closed musical figures were identified as a widely used input strategy. Using the developed pattern recognition tool, it was shown that this observation generalises across all recorded interaction data for Study I. This finding was of particular significance, as this overall preference appeared to be directly related to the fact that this input strategy allowed participants to most easily recognise their individual contribution to the collaboratively created music. This also ties in with the find-

ing that this input strategy was most effective for explaining the instrument to others, particularly underpinned by the fact that participants' demonstrations of the instruments to their companions were almost invariably based on closed music figures. In addition, the analysis of the matched data set indicated a direct association between the extent to which players organised their contributions as closed figures and their rating of perceived control. Finally, bivariate analysis of the questionnaire data indicated that the participants' sense of control was associated with other perceived qualities, such as feeling part of a creative process or their overall satisfaction with the playing experience. This provides empirical evidence for the argument concluded from the literature review that in collaborative music making the level of perceived control is associated with the enjoyment and the feeling of being part of a creative musical process.

Chapter 6

Study II: New Media Art Exhibition, Shenzhen, China

The second study of this thesis was conducted at the ‘Design Can Change’ (DCC) New Media Interactive Arts Exhibition in Shenzhen, China. *Polymetros* was invited as an exhibit and presented for one week. The exhibition was dedicated to presenting new media works and interactive art from China and abroad. It was jointly curated by the Media Lab (Shenzhen) of Hunan University and the OCT-Loft creative group¹, and was part of the 9th China International Cultural Industries Fair 2013.

In addition to the overall research goals of this thesis (see p. 17), a particular aspect of interest in Study II was to examine potential socio-cultural implications, since at the time of the study, audiences in China were not familiar with public interactivity (see following section). In Study II, the Sound Dials were introduced to expand the instruments’ sound capabilities (see *Sound Dials*, pp. 64-67). From a research perspective it became evident that this

¹OCT-Loft website: www.octloft.cn (Retrieved January 10, 2015)

new, complementary feature was particularly useful for examining mutual awareness and adoption of action between players (see pp. 132-133).

6.1 Context and Study Setting

The following paragraph is based on a short interview with the curator Wenjin Yao, focusing on her assessment of the current status of ‘interactivity’ in China (see Appendix B.3). Before returning to China in 2013, Yao had lived in France and the UK for seven years and conducted design research on the transferral of traditional Chinese cultural factors into contemporary product design (Yao and Hall, 2011).

At the time of the exhibition in May 2013, Yao considered public interactive experiences to be virtually unknown to Chinese audiences, and she was only aware of one previous exhibition of similar focus and scale held at Beijing’s National Gallery. The absence of technology-mediated interaction did not only apply to the context of art, but also to the wider context of public interactivity in general. In contrast to Europe and other Western countries, Yao confirmed that the use of interactivity as a means of audience engagement in places such as museums or science centres had not yet become commonplace in China.

While the use of commercial interactive devices such smart phones and tablets is rapidly increasing as result of the fast growth of China’s telecommunication market, Yao remarked that so far little attention had been devoted to the concept of designing interactive experiences by the professional design community. Therefore, while being open to the general public, the exhibition also aimed to raise the level of awareness for interactive art and design amongst practitioners, sponsors and policy makers.

The exhibition took place in the Overseas Chinese Town (OCT) LOFT area of Shenzhen, a former industrial zone that was transformed into an arts and cultural district with the aim of establishing a cluster for cultural and creative industries. The renovation was conducted by the state-owned OCT group and

designed largely by the Shenzhen-based architecture and design company *Urbanus*, modeled after similar urban redevelopments in Vancouver's loft area². The exhibition took place at the B10 Live³, a former industrial building converted into a music and art venue. The study was conducted from 12th to 19th May 2013.

6.2 Setup

Polymetros was installed in one of the three main exhibition spaces of the gallery. The windowless venue was dimly lit with wall spotlights and subdivided into several open fronted exhibition booths via partition panels. The booth allocated to *Polymetros* was located at one corner of the exhibition space with an approximate size of 4 by 4 metres. A LCD screen was mounted on the left wall of the booth playing a showreel of *Polymetros* for the entire duration of the exhibition, as requested by the curator. *Polymetros* was positioned centrally making it to be approachable from all sides (Figure 6.1). Due to the high ceilings and bare walls of the former industrial building, the exhibition space was very reverberant. This resulted in a lower discriminability of the instruments at the respective playing positions, as the directional effect of the individual loudspeakers was considerably reduced. In addition, the reverberant acoustics reinforced the sound bleed from an electro-mechanical sound installation located in the same exhibition space which caused a variable background noise. The user interaction was recorded via a wall-mounted video camera.

In contrast to Study I (Chapter 5), the study was conducted without assistance. The author served as a facilitator to provide visitors with some initial guidance, and conducted and coordinated data collection. As an invited artist, the author was required to be available for the audience to discuss the exhibit and to give demonstrations to sponsors and press.

²Article on OCT-Loft development: <http://www.newsgd.com/culture/culturenews/200702080044.htm> (Retrieved January 14, 2015)

³B10 Live website: <http://www.b10live.cn> (Retrieved January 10, 2015)

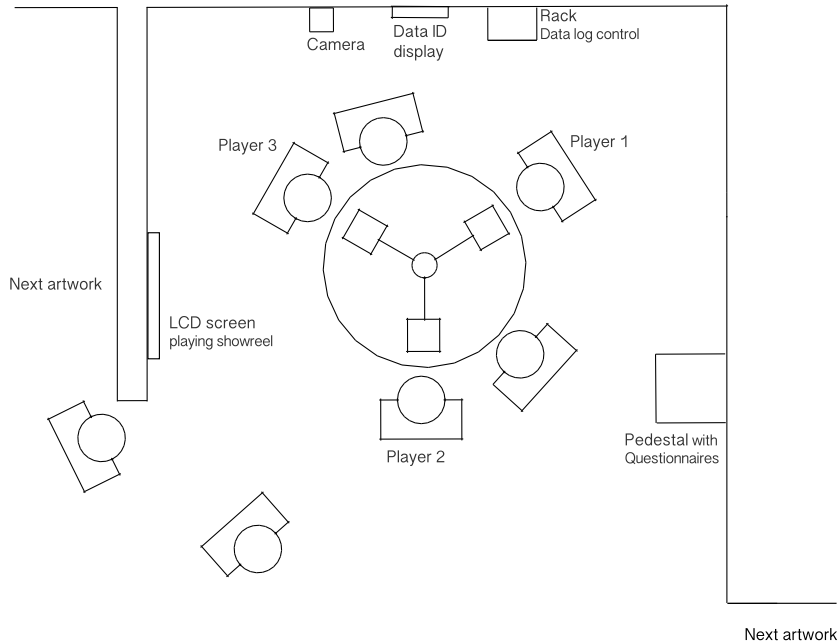


Figure 6.1: Study setup at DCC Exhibition

6.3 Data Collection

Data collection was conducted in accordance with the evaluation methodology devised for Study I as described earlier (pp. 95-97), and included questionnaires, interaction logs, and video observation. Several amendments were made to account for the particular technical and practical demands of Study II, and experience gained from Study I. These are described in the following three sections. Data collection was conducted mainly at the opening day (Sunday) of the exhibition and the following weekend (Friday - Sunday) for 6-8 hours each day.

6.3.1 Experience Questionnaire

In order to differentiate between the respondents' general appreciation for music and their formal musical experience, the music-related item S1 of Study I (I am a musical person.) was replaced by two separate statements (S1, S2) as listed

in Table 6.1. The experience-related items (E1-E7) remained unchanged. Questionnaire items, general information and consent statements were translated into Chinese (Mandarin) by a native Chinese speaker, who is fluent in English and has a research background in music psychology. During the study, the questionnaire was available in both Chinese and English (see Appendix B.1).

S1: Music is very important to me.
S2: I had formal musical training. (e.g. I play a musical instrument)
S3: I am experienced using interactive devices. (e.g. smart phone, tablet, video gaming)
E1: I felt part of a creative process.
E2: I felt in control.
E3: I felt connected to the other players.
E4: It was challenging.
E5: I liked the music we created.
E6: My playing was influenced by the playing of the others.
E7: I would recommend playing <i>Polymetros</i> to my friends.

Table 6.1: Questionnaire items Study II

6.3.2 Data Logging

In order to record the players’ interaction with the instruments, the built-in logging mechanism as was used as described earlier (p. 70). Several amendments were made in order to record the players’ use of the newly introduced Sound Dials and to facilitate easier pattern retrieval and post-processing of the data. As the study was conducted by the author alone, the MIDI remote was equipped with a long cable to allow hand-held use and mobility, and the ID display was placed to be visible from all positions in the exhibition booth. However, due to the demands of conducting all study-related tasks, the remote control could not kept at hand throughout. In total, 175 individual playing instances were

recorded and 43 of the 104 completed questionnaires could be matched to their corresponding set of interaction data.

6.3.3 Observational Data

Audience interactions were video recorded on three days during the exhibition. Due to flight baggage restrictions only one video camera could be taken. The dimensions of the exhibition booth did not allow for a camera position that provided a wide enough viewing angle, so the camera was mounted onto the pipework at a height of 3 metres at the rear wall of the exhibition booth in order to maximise the field of view. However, in order to get at least two instruments fully covered, the camera had to be aligned so that players' heads were outside the viewing angle at times, or interactors were partly occluded by audience members standing between the table and the rear wall.

Five hours of video material were reviewed and 25 individual instances of playing were selected for analysis. These were chosen mainly on the basis of the interactors' visibility (no occlusion of interface or players throughout the fragment). Each instance related to an episode of active interaction with the installation, either by one or several participants. Every instance was marked with; 1) its duration, 2) the used instrument(s), 3) the number of involved participants, and 4) whether facilitation or co-participation took place. Participants' visible conduct was transcribed in a structured format using timestamps, guided by the analysis conventions as described in detail in Chapter 4 (pp. 85-88). The transcripts are included in Appendix B.2. As all study-related tasks were conducted by the author alone, there was no possibility to write field notes during the exhibition.

6.4 Results

The following section reports and discusses the results obtained from analysing the collected data. The presentation is structured the same way as Study I.

6.4.1 Questionnaire Analysis

During the exhibition the questionnaire was completed by 104 participants (58 female, 36 male, 10 not specified) aged between 8 to 49 ($M = 25.2$, $SD = 7.0$). Available in both Chinese and English, 91 participants (87.5%) chose the Chinese survey form and 13 participants (12.5%) the English version.

Data from the questionnaires is shown in Figures 6.2 and 6.3. Each survey item is represented as an individual bar graph showing the frequencies for each response category. All bar graphs are uniformly normalised to the highest occurring frequency.

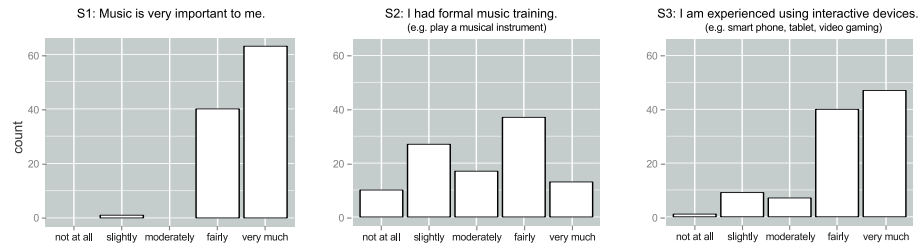


Figure 6.2: Questionnaire results of Study II (1) ($n = 104$). S1-S3 represented as individual bar graphs showing the frequencies for each response category.

Figure 6.2 shows the responses for statements S1-S3 which serve as descriptive indicators for the study participants' task-related abilities. While the self-rating of their general appreciation of music is highly skewed toward positive responses (S1), the rating of their musical skills is more uniformly distributed across all response categories and indicates a diverse level of practical musical experience. The majority of the participants considered themselves as experienced users of 'everyday' interactive technology (S3).

Figure 6.3 shows response to the experience-related items (E1-E7). The major-

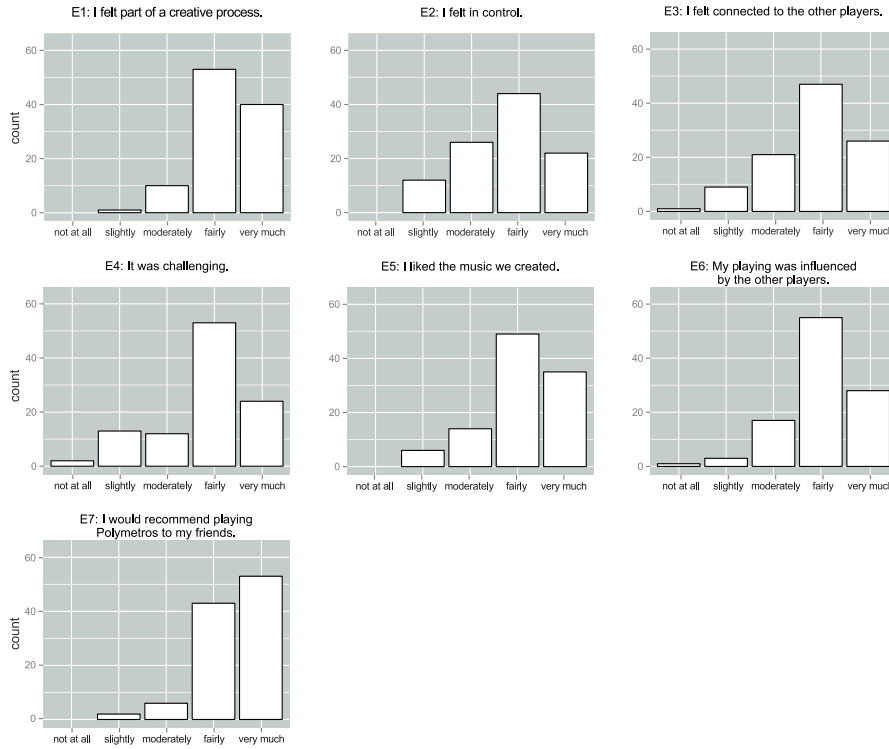


Figure 6.3: Questionnaire results of Study II (2) ($n = 104$). E1-E7 represented as individual bar graphs showing the frequencies for each response category.

ity of respondents stated they would recommend playing to their friends (E7, top-two box score 92%, median = *very much*), which indicates a high overall satisfaction with their playing experience. The second highest positive rating corresponds to feeling part of a creative process (E1, top-two box score 89%, median = *fairly*). In combination with the responses to item E3 ('feeling connected to others') and E6 ('playing influenced by others') the results suggest that the majority rated their playing experience as an act of shared creative participation. Notable is the relatively high result for how respondents rated the other participants' influence on their playing, in comparison with the other two studies (E6, top-two box score 80%, median = *fairly*). Therefore, particular attention was devoted to instances of observable mutual influence between players during the analysis of interaction and video data. The findings are presented later (pp. 132-133).

The response relating to the players' perceived control (E2) is moderately skewed around *fairly*. The rating of the perceived challenge (E4) shows a central tendency at *fairly* which contrasts with the responses in Study I (and Study III, see Chapter 7), where the ratings were more evenly distributed across all response categories.

In summary, the survey results indicate a positive overall response in terms of playing experience and participatory aspects. Characteristic features are the relatively high ratings of other players' influence (E6) and perceived challenge (E4).

As a final remark, it was noted that the response patterns of the experience-related items appeared to show a tendency towards ratings centred around the response category *fairly*. Therefore, it seems sensible to consider the possibility that this characteristic might be influenced by effects of cross-cultural differences in response behaviour. Several studies have indicated that Asian respondents have a lower extreme response style (ERS) in comparison with respondents from Western countries (e.g. Chun et al., 1974; Roster et al., 2003; Dolnicar and Grün, 2007). This is associated with a lower likelihood of using the extremes of the answering scale, which leads to more centred, 'narrower' response patterns. However, it has to be noted that the questionnaire responses to item E7 ('recommend playing to others') and S1 ('musical appreciation') *do show* a strong tendency towards the upper endpoint of the scale (median of both = *very much*), whereas S2 ('formal musical experience') is rather uniformly distributed across all response categories.

Bivariate Analysis

In order to examine if the participants' rating of experienced control is associated with other perceived qualities of their playing experience, the *gamma* correlation coefficient was used as described in detail earlier (Study I, p. 100). Table 6.2 shows the correlation matrix of all questionnaire items. Correlations that are omitted as they probe the same aspect are marked by square brackets (cf. Study

I, p. 102).

	S1:	S2:	S3:	E1:	E2:	E3:	E4:	E5:	E6:
S1: Appr. of music	-								
S2: Musical skills	0.082	-							
S3: Tech. exp.	0.204	0.347**	-						
E1: Process	0.197	0.085	-0.077	-					
E2: Control	0.207	0.007	-0.033	0.522****	-				
E3: Connection	0.207	0.132	0.067	[0.660****]	0.501****	-			
E4: Challenge	0.052	0.211	-0.055	0.143	-0.021	0.113	-		
E5: Like	0.345*	0.143	0.041	0.523***	0.336**	0.458***	0.218	-	
E6: Influence	0.085	-0.092	-0.011	0.219	0.032	[0.426***]	0.126	0.120	-
E7: Recommend	0.372*	0.095	0.054	0.687****	0.503***	0.739****	0.517***	[0.734***]	0.484**

**** Significant at the 0.0001 level (2-tailed)

*** Significant at the 0.001 level (2-tailed)

** Significant at the 0.01 level (2-tailed)

* Significant at the 0.05 level (2-tailed)

Table 6.2: Correlation matrix Study II (n = 104). *Gamma* coefficients between all questionnaire items.

When focusing on the aspect of perceived control (E2), the data revealed highly significant associations between ‘feeling in control’ and ‘feeling part of a creative process’ (E2/E1, *gamma* = 0.52, $p < 0.0001$), ‘feeling in control’ and ‘recommend playing to friends’ (E2/E7, *gamma* = 0.50, $p < 0.001$), ‘feeling in control’ and ‘feeling connected to other players’ (E2/E3, *gamma* = 0.50, $p < 0.0001$) and a significant association between ‘feeling in control’ and ‘like the created music’ (E2/E5, *gamma* = 0.34, $p < 0.01$). Interestingly, the items associated with perceived control (E2) are identical to Study I, and show similar magnitudes (cf. Study I, p. 102). In summary, the results indicate an association between participants’ perceived control and their sense of participation (E1, E3) and enjoyment (E5, E7).

6.4.2 System Interactions

As seen in Study I, *Polymetros* had a strong attraction for the audience, created a ‘buzz’ (Brignull and Rogers, 2003) and drew further passers-by towards the exhibition booth. At most times during the study, active players were surrounded by a number of spectators. As a result, visitors often evolved gradually from observers to active participants, as reported for large public multi-touch displays (Peltonen et al., 2008; Marshall et al., 2011).

In comparison to the audience in the UK in Study I, visitors appeared to be



Figure 6.4: Polymetros at the DCC Exhibition, Shenzhen

more reluctant to approach *Polymetros* with a ‘trial-and-error’ mentality. Often, audience members turned to the LCD screen to watch the showreel in order to, as it appeared, find out how to play before trying it in practice. Several audience members approached the facilitator directly to ask “how to play?” before trying it on their own, while others would ‘stick around’, showing interest but only overcoming their hesitation to engage actively after verbal encouragement by the facilitator. This links in with the finding that the activity of a ‘compere’ can significantly remove “many of the social inhibitors that prevent people from engaging in interaction”, as reported by Akpan et al. (2013) for public, interactive wall displays.

Interface Interaction

In Study II the Sound Dials were introduced, allowing each player to influence their instrument’s sound via a bidirectional control dial. As described in detail earlier (p. 64), these were devised as a *complementary* feature to expand the instruments’ sound capabilities and the players’ scope of action. As the Sound Dials are not essential for playing the instrument, they were left entirely to be discovered by the players. Besides a marker line and a scale indicating the

possible amount of rotation, the dials were not labelled, and their function was not introduced when initial guidance was provided by the facilitator. This allowed for the study of how the Sound Dials were encountered without potential bias of previous explanations.

The observations indicated that only a small number of players uncovered the dial's function and, as a consequence, incorporated it into their playing. Quite a few instances (8 of 25) showed players touching the dial, but turning it just a small amount whilst trying to work out its purpose. As such tentative input did not lead to a salient acoustic effect, they were not able to understand the dial's function and usually did not further engage with it.

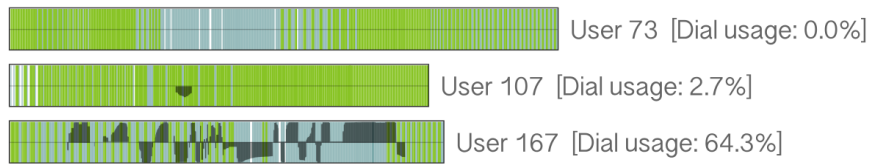


Figure 6.5: Data analysis tool: Dial usage visualisation for three instances.

In order to examine how these observations generalise across all recorded playing instances ($n = 175$), *dial usage* was defined as the measure of the percentage of played notes modified via the dial. In addition, visualisation was extended to display the players' usage of the dial over time, superimposed to the bar graph representation introduced earlier (Study I, pp. 107-107). For illustration, Figure 6.5 shows visualisation and dial usage for three selected playing instances from the gathered data set. In the first instance (User 73), the centred line indicates that the dial remained in its default position and was not used by the player at all. The single notch in the second instance (User 107) relates to a singular, negative turn of the dial, whereas the biphasic waveform in the third instance (User 167) depicts the player's extensive use of the dial in both directions. The amplitude of the waveform corresponds to the dial's degree of rotation.

Averaged over all recorded playing instances ($n=175$), dial usage was only 6%, and 94 players did not make use of the dial at all (54%). In the remaining

instances the dial usage was generally low, containing only 20 instances with a dial usage greater than 15%. Visual inspection showed that in many instances low dial usage referred to a singular input event, where the dial was only moved a small amount, similar to the example shown in Figure 6.5 (User 107). These instances are very likely to relate to tentative input attempts, as described earlier, that did not reveal the dial's function.

In contrast, the data showed that the small percentage of players ($n = 20$) who were likely to have uncovered the dial's function (dial usage $>15\%$) incorporated it to a considerable extent into their playing (dial usage: $M = 38\%$, $SD = 18$). In summary, while aiming to draw on peoples' general experience with similar controls used in consumer electronics (e.g. volume or tone controls), the findings indicate that the Sound Dials were not intuitively understood by the majority of study participants. The observations illustrate that this was not easily overcome by participants' experimentation since the commonly applied, tentative input approach did not result in distinctive auditory feedback.

A potential design solution would be to adapt the functionality so that slight movements trigger a drastic effect on the sound. However, the maximum intensity of the sound effects is limited in order to avoid masking the sound of the other instruments, as discussed in detail earlier (p. 64). This would 'downgrade' the role of the dial from providing dual, continuous levels of sound manipulation, to a binary control, which might be better implemented, for example as a big dome push button. However, no amendments were made to allow for a direct comparison with the results of the following study (Chapter 7, pp. 138-163), which took place in the context of a large-scale music festival, in order to examine potential differences in dial use.

Input Strategies

Similarly to Study I, field and video observations indicated that most players had a strong preference for 'closed musical figures' when creating their musical phrases on the instrument's grid. As described in detail earlier in Chapter 5

(p. 106) and illustrated in Figures 5.4 and 5.5(a), closed figures refer to continuous, horizontal or diagonal sequences of notes. These observations were confirmed by data analysis across all recorded playing instances ($n = 175$). The summative overview, as depicted in Figure 6.6, shows that 56% of the musical material was organised according to the properties of closed musical figures. The overall distribution across all three categories is notably similar to Study I (see Figure 5.7, p. 107)

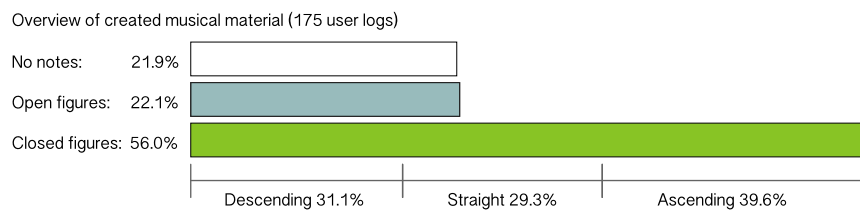


Figure 6.6: Percentages of occurrence of each pattern category across all recorded instances of playing ($n = 175$).

In keeping with the findings from Study I, observations suggested that the players' general preference for closed musical figures was related to the fact that, in comparison to more complex or 'scattered' patterns, they were easier to identify and 'trace' within the overall musical output. As a result, these figures readily facilitate the audience's understanding of the user interface and interaction concept. This was illustrated by participants' use of closed figures when explaining the instrument to their companions, in a similar way to that already observed in Study I (pp. 108-110).

Although it seemed reasonable to expect that once players had understood the instrument through the use of such simple patterns, they would progress to more complex patterns, both observations and data analysis showed that the use of closed figures remained steady over time. Interestingly, this was also the case for advanced players who had developed above average playing skills due to particularly long or repeated engagement with the instrument. Their recurring use of closed musical figures suggests that their simplicity and recognisability retained their appeal even after participants had discovered more complex ways

of playing.

The pursuit of recognisability and clear feedback also appeared to manifest itself in another input strategy developed around closed figures, that had also been observed in Study I. In several instances (7 of 25) players modified their figures over time in ways that suggested a systematic effort to make edits as distinct and ‘traceable’ as possible. With respect to the current loop length, they would change just a single event per playback cycle, then listen to the new variation for at least one repetition before making another single edit.

Unlike Study I, the matched data set in Study II did not indicate a direct association between the extent to which players used closed musical figures, and their reported level of control. Besides the relatively small size of the subset ($n = 43$), a potential cause may lie in the bias introduced by the systematic use of this input strategy for facilitation.

In summary, the reported input strategies appeared to be strongly related to the players’ attempts to affirm their control throughout playing by creating and modifying their contributions in ways that provided salient feedback and facilitated recognisability.

6.4.3 Social Interactions

Forms of Participation

As seen in Study I, audience members who already knew each other frequently played together on a single instrument of *Polymetros*, and pairs were most common. Two or more persons collaborating on one instrument were regularly observed in the annotated video footage (13 out of 25 instances). Co-participants could be seen jointly exploring an instrument through action and verbal interaction. They collaboratively created and edited patterns, tried out different functions and discussed them together, explaining their actions to each other as noted earlier (p.129). A contextual factor that prompted co-participation was the high number of visitors over long periods of the study. Audience mem-

bers who arrived together often found only one instrument available or, after having to wait their turn, took over the first one that became vacant. However, even if another instrument was available, companions often approached the same instrument together in order to figure it out together. At a later stage of play, companions would sometimes split up to take over different instruments. This occurred in around half of the annotated playing instances containing co-participation (6 of 13).

Players were also observed to sometimes return to co-participation. In one example, two women were playing on different instruments whilst occasionally chatting across the table. When one of them was approached by a child, she left her instrument and rejoined her companion. A potential reason for this may have been that she felt that her personal space was being ‘invaded by the child’ (cf. Marshall et al., 2011). Together with her companion, she continued playing collaboratively on one instrument for another 10 minutes.

These observations suggest that co-participation may also be preferred as a way to manage social discomfort, or the reluctance to approach an as yet unknown device on one’s own in the presence of strangers. It appeared likely that similar social factors were responsible for the fact that *active engagement* between strangers was rarely observed during the study. To recap, active engagement refers to situations where several players actively seek to coordinate their playing over a certain period (p. 111). Nevertheless, many questionnaire respondents stated that they *felt* connected to the other players (top-two box score: 70.2%, median = *fairly*, see Figure 6.3). In addition, a high percentage of respondents stated that their playing was either *fairly* (53%) or *very much* (27%) influenced by the other players. Therefore, particular attention was paid to identifying instances of mutual influence between players in the video footage. A general problem, however, was how to determine if a certain action or input strategy stemmed from a player’s own initiative, or was picked up from another player or facilitator. This could occur either during play or beforehand as a spectator. Hence, a clear identification of the origin of certain actions was not always

possible.

In this respect, the Sound Dials proved useful. In contrast to note input on the grid, the use of the Sound Dial is a discrete and self-contained action. Additionally, it was not introduced by the facilitator at any point. Importantly, the generally low usage of the dials reported earlier (p. 127) made this function stand out as a ‘distinct’ action that could be clearly identified in the video footage. In at least six of the annotated instances it appeared likely that dial usage was adopted from others. In these cases, the players’ first observed use occurred while the dial was being extensively used by another player. In four instances the exact gesture was adopted (e.g. turn and hold in maximum position). Although the use did not necessarily lead to understanding of the feature, the observations indicate mutual awareness and adoption of actions between players. While, in general, clear identification of the origin and mutual adoption of more complex interactions was difficult due to the uncontrolled conditions, an example is now presented whose particular structure allows such implications to be made.

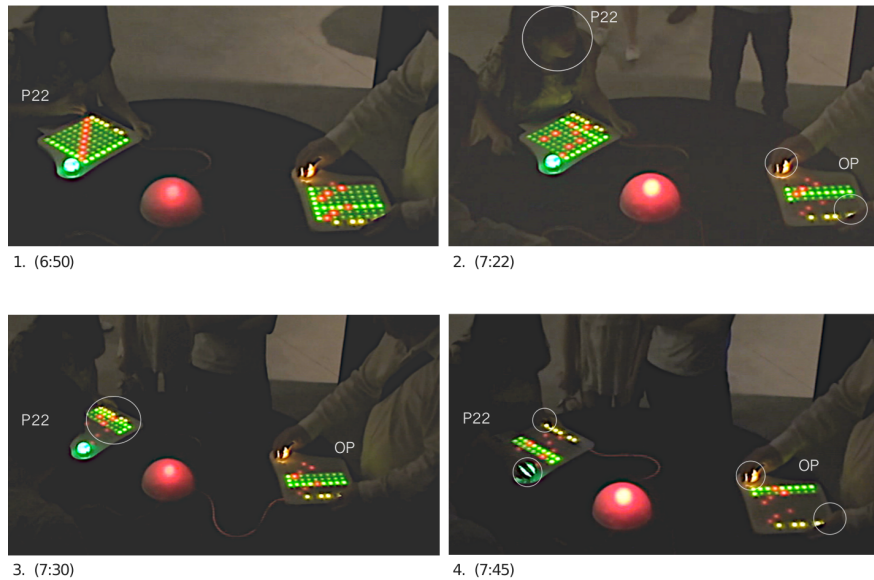


Figure 6.7: Awareness and adoption between players

To set the scene for the actions depicted in Figure 6.7, the young women on the left (P22) had already spent around 10 minutes playing the instrument on her own. After a brief guidance by the facilitator at the beginning, P22 appeared to be confident with the basic interaction concept. P22 performed commonly observed input strategies (e.g. varying ‘closed musical figures’) and seemed entirely focused on her instrument (frame 1). During this time P22 had not yet changed the loop length (8 steps) or used the loop-shift buttons. In frame 2, P22 looks up and observes another player (OP) across the table (frame 2). OP makes extensive use of the loop-shift function to dynamically move a short selection (3 steps) across the grid. In frame 3, P22 sets the loop length to three steps and starts to use the loop-shift function in the same way. In addition, P22 grabbed and held the Sound Dial (frame 4) in the same way that OP had (frame 1-4). This example illustrates how more complex ‘interaction styles’ may be imparted between players (cf. Xambó et al., 2013).

In summary, the findings highlight the prevalence and significance of co-participation among familiar audience members in highly frequented settings and mutual awareness and adoption of action between unacquainted players.

Dwell Time in Context

As introduced earlier (p.112), dwell time refers to the period that an audience member is actively interacting with one of the instruments. Based on 175 interaction logs, the average dwell time in Study II was 2.8 minutes ($SD = 2.5$). In order to examine if participants’ dwell time was associated with how they rated their experience in the questionnaire, Kendall’s *tau* coefficients were calculated between the players’ dwell time and their experience-related item responses (E1-E7) in the matched data set ($n = 43$). As for Study I, no associations between playing time and experience ratings were found.

Therefore, video analysis was undertaken to identify potential reasons for audience members to stop playing or leave the installation. The observations indicated that players were more likely to withdraw if other visitors showed

notable interest in their playing activity. Same players (4 of 25) were observed leaving their instrument when confronted with spectators watching their interaction from the immediate vicinity. In one case an active player withdrew from the installation immediately when an apparently unacquainted audience member reached out for his instrument to make additional input. In keeping with the observations in Study I, this suggests that some players felt obliged to leave in order to give way for other visitors.

Although most of the data was collected during weekend days, when the exhibition was highly frequented, a subset of the interaction logs ($n = 48$) belongs to playing instances on week days, which were much less well attended. The comparison between dwell times on week days and weekends shows a higher average dwell time during week days (3.3 min, $n = 48$) compared to weekend days (2.6 min, $n = 125$). Although this difference is less distinct than in the pilot study (where the data allowed for a similar comparison as reported earlier, see p. 113), the finding supports observations suggesting that dwell time is influenced by audience dynamics in highly frequented exhibition contexts.

Other instances of players leaving were initiated by the companion(s) they were associated with, either explicitly, by indicating their will to move on, or implicitly, by moving away whilst the player was still engaged with the installation. In addition, situations occurred during the study where participants had to quit solely due to external necessities. These included short-term outages of the installation due to a software failure and a power cut, as well as temporary shut downs demanded by the curator several times a day to facilitate music performances in the adjacent space.

In summary, similar to Study I, the findings suggest that participants' dwell time was likely to be determined by contextual and social factors rather than how they perceived their individual playing experience.

6.5 Reflective Summary

This section concludes the second case study undertaken to investigate the main research goals of this thesis to, 1) gain a descriptive understanding of collaborative musical experiences in public, and 2) examine the value of perceived control in such collaborative experiences. As the study was conducted in China, at a time when audiences there were not yet familiar with public interactivity, an additional interest was to examine whether this was reflected in the audience interaction with the installation. The main findings are summarised in the next section. Overall analysis of all three studies, discussion of the applied evaluation approach, and implications for design are provided in a dedicated chapter (Chapter 8, pp. 164-184).

Social and Contextual Aspects: In general, in contrast to Study I, the exhibition audience showed a slightly more hesitant attitude in approaching the installation. In particular, participants appeared to be more reluctant to explore an instrument with a hands-on, trial-and-error approach, preferring to consult either the facilitator or showreel first in order to ‘do it right’ from the outset, or to proceed hesitantly interacting at a slow pace. It seemed very likely that these tendencies were related to the fact that many audience members were not used to active interaction with an artwork. Several audience members appeared to be unsure whether they are even allowed to touch it, in particular when nobody else was playing. In this context, it is also interesting to recap that the questionnaire item probing the perceived challenge received the highest score among all three studies.

Co-participation through companions sharing one instrument was the most common social configuration amongst audience members. Analysis indicated that co-participation was to some extent fostered by the installation being in high demand (so only one instrument available). Moreover, sharing also appeared to be a widely used strategy to manage social discomfort and the reluctance to approach and figure out a yet unknown device on one’s own in the presence

of strangers. A similar phenomenon was pointed out by O'Hara et al. (2008) and Sheridan et al. (2007) and observed by Brignull and Rogers (2003) around large public displays. As in Study I, the findings indicated that the participants' dwell time was more likely to depend on contextual and social factors rather than being directly determined by how they rated their playing experience.

Interactional Aspects: The study showed that the newly introduced Sound Dials were not intuitively understood by most players and this was rarely overcome by experimentation, since participants' typically tentative input did not provide strong enough acoustic feedback. These observations were supported by the analysis of the gathered system interaction data. The dials' infrequent use allowed examination of tacit awareness and adoption of actions amongst players and it was shown that participants picked up actions and styles of interaction from other players. This tacit 'mimicking' of actions is very similar to what was observed amongst expert musicians improvising at a musical tabletop in a laboratory setting (Xambó et al., 2013).

As in Study I, closed musical figures were a widely popular input strategy and their common use was shown to generalise across all recorded playing data. Again, this preference seemed closely related to the fact that for players such figures were easy to recognise and follow in the collaboratively created music. Likewise, this strategy was most effective for explaining the instrument and typically used by participants when demonstrating it to their peers. Interestingly, observations and data analysis showed that overall the players' use of these simple patterns remained steady throughout their playing. Even more advanced players, having explored more complex patterns, then fell back on this input strategy. In a more general sense, this could lead to the conclusion that in such a multi-user context players tend to prefer certainty through constant affirmation of action over experimentation with the risk of losing control. The bivariate analysis of the questionnaire data showed very similar results to Study I in relation to the aspect of perceived control (identical pairs of association, similar

magnitudes), which further strengthens the evidence that in collaborative music making participants' perceived level of control is related to their enjoyment and sense of feeling part of a creative process.

Chapter 7

Study III: Sónar Festival 2013, Barcelona

The third study was conducted at the Sónar Festival¹ in Barcelona, Spain, one of the world's biggest festivals for electronica and electronic dance music. The Sónar Festival 2013 hosted more than 130 music acts over three days and was attended by 121,000 visitors. *Polymetros* was invited as an interactive exhibit² and presented at the festival's day-time program, which incorporated a wide range of media, art and technology oriented events. In Study III, the situated context shifted from a museum and exhibition setting to the mixed-use environment of a large-scale festival setting. Hence, along with the overarching goals of this thesis (see p.17), a particular focus of Study III was to examine if, and in what ways, the setting's dedicated focus on music and technology, and its orientation towards dance music in particular, would be reflected in the audience interaction with the installation. Therefore, *Polymetros* was presented with two different sound sets: one was identical to the minimalist music inspired sound set as used in Study I and II, the second was inspired by electronic dance music.

¹<http://sonar.es/en/> (Retrieved January 16, 2015)

²http://sonar.es/en/2013/prg/sm/polymetros_23 (Retrieved February 8, 2015)

7.1 Context and Study Setting

The study took place from 13th to 15th June 2013 at the 20th Sónar Festival in Barcelona. It was carried out at Sónar+D, the festival area dedicated to new media art and technology. It took place at the Fira Montjuïc exhibition centre, closely integrated with the music line-up, as this was also the festival's day-time music venue with one large outdoor stage and three indoor stages. The Sónar+D area combined showcases of interactive installations and activities such as workshops and hackathons, with commercial demonstrations of products and services. These were mainly related to music consumption and production, multimedia technology and maker culture. Several companies presented music-making tools (e.g. synthesisers, midi controllers) targeting festival goers interested or actively involved in electronic music production. Workshops offered included DIY music electronics and the use of commercial DJ software. There were several indoor and outdoor bar areas and from midafternoon onwards, an increasing number of audience members were consuming alcoholic beverages. During the three days of the festival, the Sónar+D area was open to all festival visitors from 12 noon until 10 p.m. According to the review sent out by the organisers after the festival, the day-time program was attended by 42,000 visitors.

7.2 Setup

Polymetros was located in the Market Lab of Sónar+D, an exhibition area subdivided into 29 open fronted booths via walls made out of cardboard boxes. The majority of them were occupied by commercial exhibitors. Due to the small dimensions of the assigned booth (2.8 by 2.4 metres), *Polymetros* had to be positioned so that it protruded from the booth in order to make all instruments approachable for the audience (Figure 7.1).

As the regulations of the Market Lab did not allow for amplified sound projection, the installation's output level had to be authorised by the organisers. As

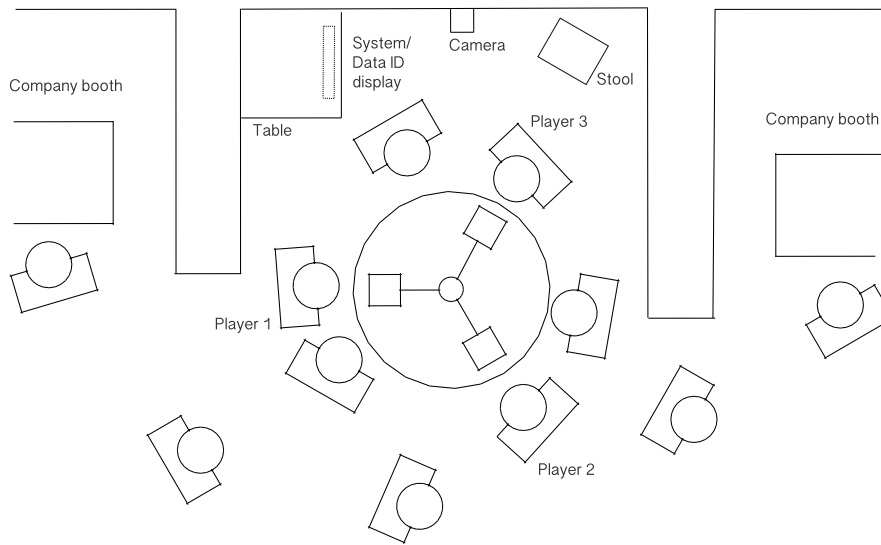


Figure 7.1: Study setup at Sónar Festival 2013

a result, *Polymetros* was set to a moderate playback level, which was still sufficient with regard to the average crowd noise in the exhibition area. However, due to the fact that a number of exhibitors disregarded the restrictions, there was an extremely high level of background noise at times, masking the output of the installation. As an example, a nearby booth projected different audio jingles over the entire Market Lab area for several minutes every half an hour via a PA system at extremely high volume. During this period, players and bystanders were hardly able to hear the output of *Polymetros*, even if the playback level was temporarily raised. In these situations, players were frequently observed to bend forward to bring their ears as close as possible to their instrument. Other noise interferences came from the nearby ‘Hack Day’ stage from which announcements, jingles and presentations were projected across the Market Lab at irregular intervals.

Another challenging contextual factor was the constrained space in combination with the high visitor turnout. Due to crowds of visitors approaching the open front of the booth from all sides, the research team (author and one assistant)

was often ‘cornered’ at the back of the booth. As a result, they were not able to move freely around the table which complicated questionnaire handling and facilitation. However, due to the fact that the majority of visitors appeared to be able to work out the instrument on their own, or in cooperation with others as discussed later (p.157), on average, less facilitation was provided in comparison to Study I and II. On request of the organisers, time frames and sequence of the two sound sets were identical at all three days of the festival. From noon till 3 pm, *Polymetros* was showcased with Sound Set I (Minimal Music), and from 3.15 pm till 10 pm with Sound Set II (Electonica/Techno).

7.3 Data Collection

Data collection was conducted by the author with the help of one assistant. It followed the evaluation methodology applied in Study I and II comprising questionnaires, interaction logs, and video observations. Several amendments were made to cater for the study context at the Sónar Festival. These are described in the following sections.

7.3.1 Experience Questionnaire

Due to the festival context, a general interest in music could be expected from the audience. In addition, the Sónar+D area attracted musicians and festival goers who already had some experience with digital music tools. In order to elicit detailed information about participants’ musical preferences, activities and proficiency, the introductory section of the questionnaire was adapted accordingly as listed in Table 7.1 (S1, S2, S3). For the self-rating of musical proficiency (S1) the available response categories were:

none - beginner - intermediate - semi-professional - professional

Musical preferences (S2) and, if applicable, active musical experience (S3), could be specified as free-text responses. The experience-related items (E1-E7) remained unchanged. On the back of the form, along with the consent statement,

a text field for additional feedback was provided (Co). The questionnaire was translated into Spanish by one translator, and reviewed by a second, both fluent in English and Spanish. During the study, the questionnaire was available in both Spanish and English (see Appendix C.1).

S1: How would you rate your musical proficiency?
S2: What type and genre(s) of music do you like most.*
S3: If you are an active musician, please specify what you do.* (e.g. DJ, producer, pianist, singer...)
E1: I felt part of a creative process.
E2: I felt in control.
E3: I felt connected to the other players.
E4: It was challenging.
E5: I liked the music we created.
E6: My playing was influenced by the playing of the others.
E7: I would recommend playing <i>Polymetros</i> to my friends.
Co: If you have any other feedback for us please share and let us know.*

* free-text fields provided

Table 7.1: Questionnaire items Study III

large public

7.3.2 Data Logging

Players' data input was recorded via the built-in logging mechanism as described earlier (p. 70). The MIDI remote to control data recording was placed on a side table in a corner of the booth that also served as a rack for the questionnaire forms. As only one LCD screen was available, this served as ID display and system monitor and, due to space constraints, it was placed under the table. In addition to the ID code (if available), each questionnaire was marked with an identifier to indicate which sound set the respondent played with.

In total, 221 individual playing instances were recorded, 132 for Sound Set I (Minimal Music), and 89 for Sound Set II (Electronica/Techno). See pages 67-69 for detailed description of the sound sets. 74 of the 221 completed questionnaires

could be matched with their corresponding interaction data – 41 related to Sound Set I, and 33 to Sound Set II.

7.3.3 Observational Data

For video recording the audience interactions, a camera was mounted on top of the rear wall of the booth (approx. 3 metres high). While this positioning allowed for video recording of all three instruments, individual instruments were regularly occluded by spectators, participants using the table to fill in a questionnaire, or members of the research team ‘cornered’ at the back of the booth due to the crowds. Additional, complementary video material was taken by the research assistant with a hand-held, digital SLR camera.

Six hours of video material from the three days were reviewed and 40 individual instances of playing were selected for analysis, 20 for each sound set. The instances were chosen mainly on the basis of visibility (no occlusion of the interface or participants throughout the fragment). Due to the different mode of operation of instrument 1 (drum machine) in Sound Set II, 10 of the 20 instances were selected to involve instrument 1. Each instance was marked with; 1) its duration, 2) Sound Set, 3) instrument(s) used, 4) number and description of participants involved, and 5) whether facilitation or co-participation took place. Participants’ visible conduct was transcribed in a structured format using timestamps, guided by the analysis conventions as described in detail in Chapter 4 (pp. 85-88). The transcripts are included in Appendix C.5.

7.4 Results

The following section reports and discusses the results obtained from analysing the collected data. The presentation is structured the same way as Study I and Study II.

7.4.1 Questionnaire Analysis

During the three-day showcase, the questionnaire was completed by 221 participants (71 female, 145 male, 5 not specified) aged from 14 to 52 ($M = 30.4$, $SD = 6.8$). 128 questionnaires related to Sound Set I (Minimal Music), and 93 to Sound Set II (Electronica/Techno). Available in Spanish and English, 122 participants (55.2%) used the Spanish questionnaire form and 99 participants (44.8%) the English version.

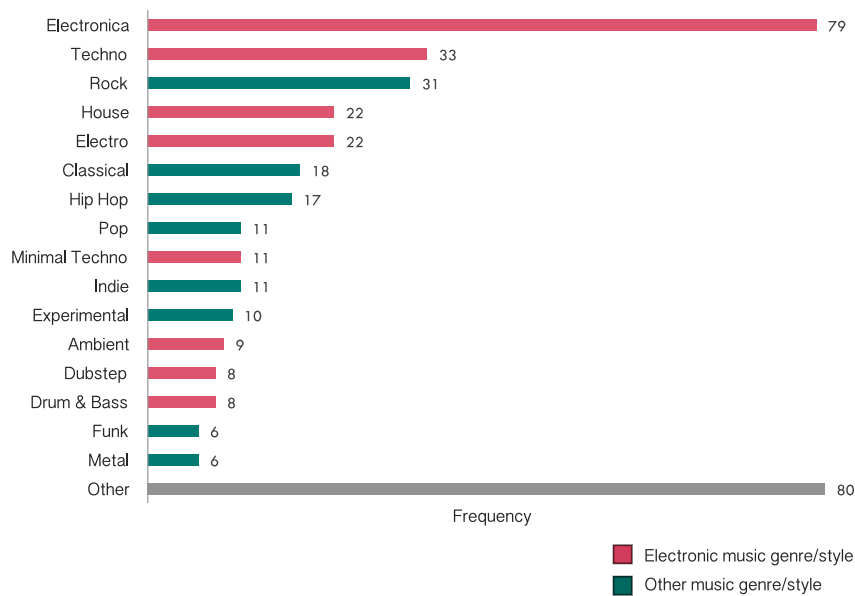


Figure 7.2: Participants' reported musical preferences

Figure 7.2 shows the participants' musical preferences. 192 respondents (87%) indicated one or more preferences, giving 382 responses in total, 29 participants (13%) left the text field blank. 'Other' was comprised of genres/styles that were given five times or less (see Appendix C.2). Visual inspection shows that the greater part are styles of electronic dance music (marked in red). The most frequently used term 'Electronica' can be considered as an umbrella term encompassing various styles of electronic music.

In terms of musical activities, 91 participants (41%) responded, giving 132 responses, whilst 130 respondents (59%) left the text field blank. The most com-

monly specified activities were ‘Producer’ (43) and ‘DJ’ (34). Other activities, which were stated nine times or less, can be found in Appendix C.3. The greater part of participants who responded to this item (41%) referred to musical activities that involve digital technology.

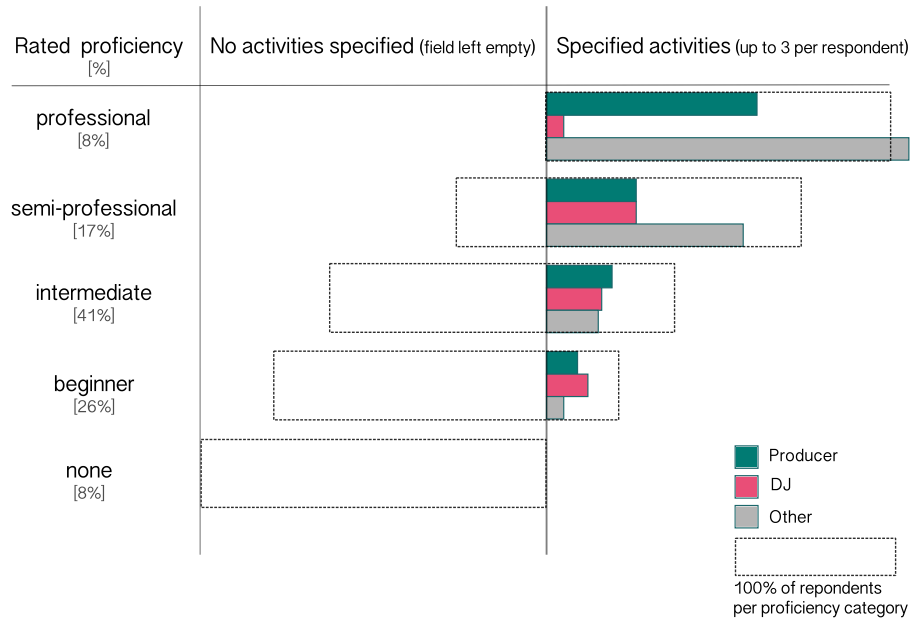


Figure 7.3: Self-rated musical proficiency vs. specified activities (n = 221)

The ranked results of self-rated musical proficiency (S1) for all respondents are: *Intermediate*: 41%, *beginner*: 26%, *semi-professional*: 17%, *professional*: 8%, and *none*: 8%. Figure 7.3 illustrates the relationship between participants’ self-rated musical proficiency and their specified musical activities. For each proficiency category the specified activities (right side), or lack of response (left side) were plotted. As a result, the diagram shows a congruent relationship between musical proficiency and specified musical activities.

Additional free-text feedback (Co) was provided by 49 of the 221 respondents. These mostly very short comments were classified into three categories: 1) commendatory feedback (e.g. “great fun”, “luv it” (sic), “sell it!”), 2) suggestions for improvements (e.g. “more steps 16!” , “change of sounds and more control over tempo”), and 3) suggestions of use (“for children at school!” , “for com-

petitions of group music-making”). The categorised list of all comments can be found in the Appendix C.4. A notable characteristic is the frequent use of technical terms (e.g. “effects!!! delays, reverbs..”, “pattern recording”, “more oscillators”, “the control of the decay should be faster [..]”).

In summary, the demographic results reflect the expected preference for electronic music styles among the audience and indicate that some participants were familiar with music technology.

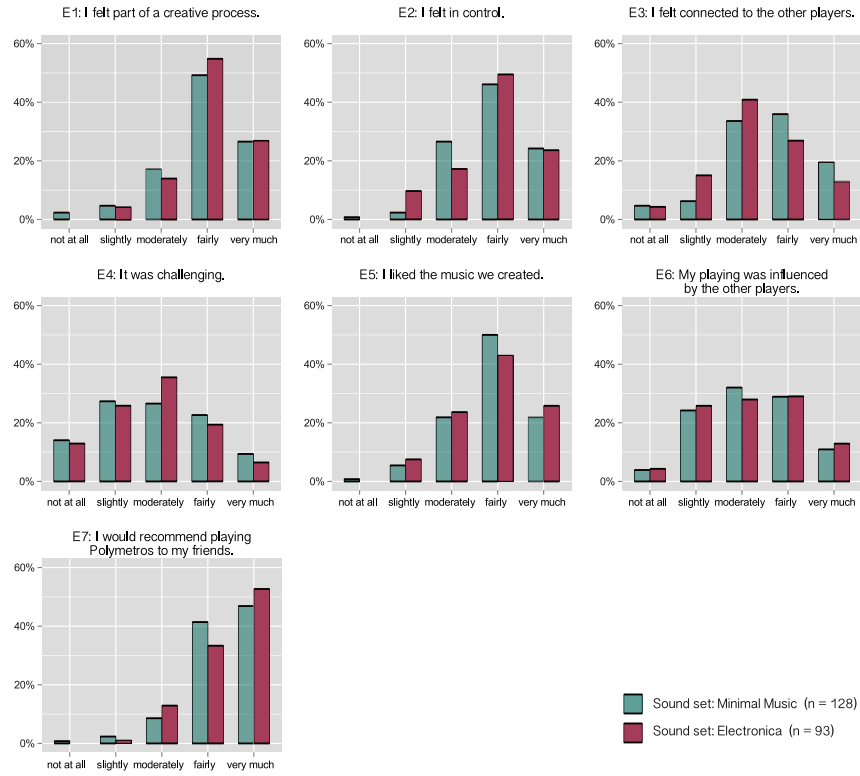


Figure 7.4: Questionnaire results of Study III. E1-E7 represented as combined bar graphs showing the corresponding responses in percentage for both sound sets.

Figure 7.4 shows the responses to the experience-related items (E1-E7) for both sound sets. Each statement is represented as an individual bar graph showing the corresponding response pattern in percentage. To enable direct comparison,

both sets of bar graphs are normalised respectively to their sample size.

The most salient characteristic of this comparative representation is the high level of similarity between the responses for the two different sound sets. Across all seven items, the results show very similar distributions for both conditions. Along with S1 ('musical proficiency', not included in Figure 7.4), the items E1, E2, E4, E5, and E6 have the same median values for both conditions. Only items E3 ('connected to others') and E7 ('recommend to others') have different medians for each conditions (E3, Sound Set I: median = *fairly*; Sound Set II: median = *moderately*; and E7, Sound Set I: median = *fairly*; Sound Set II: median = *very much*). Conducting a Mann-Whitney U test for both items indicates that the difference in medians is only significant for E3 ($Z = 2.38$, $p < 0.05$, $r = 0.16$). However, the interpretation of the corresponding effect, according to Cohen's effect size thresholds (see Study I, p. 101), indicates only a weak effect for E3.

Due to the high degree of similarity between both conditions, further results are reported in combination. The majority of participants expressed a high overall satisfaction by indicating that they would recommend playing to their friends (E7, Sound Set I: top-two box score 88%, Sound Set II: top-two box score 86%). The second highest positive rating for both sound sets relates to feeling part of a creative process (E1, Sound Set I: top-two box score 76%, Sound Set II: top-two box score 82%). E2 ('feeling in control') and E5 ('like the created music') also show relatively high ratings, both moderately skewed around *fairly*. In comparison, the ratings for perceived challenge (E4) and influence of other players (E6) are more widely dispersed showing a greater variability across all response categories (both medians = *moderately*).

Bivariate Analysis

As in Study I and II, the *gamma* correlation coefficient (Study I, p. 100) was used to examine if participants' rating of experienced control was associated with other perceived qualities of their playing experience. Correlation matrices

were calculated for each sound set (Table 7.2 and 7.3, square brackets marking correlations omitted since they probe the same aspect (see Study I, p. 102).

	S1:	E1:	E2:	E3:	E4:	E5:	E6:	E7:
S1: Proficiency	-							
E1: Process	-0.013	-						
E2: Control	0.100	0.316**	-					
E3: Connection	0.091	[0.355**]	0.268*	-				
E4: Challenge	-0.101	0.155	0.036	0.476****	-			
E5: Like	-0.193	0.428****	0.321**	0.521****	0.492****	-		
E6: Influence	0.079	0.193	0.003	[0.631****]	0.439****	0.422****	-	
E7: Recommend	-0.116	0.489****	0.193	0.353**	0.231*	[0.524****]	0.359**	-

**** Significant at the 0.0001 level (2-tailed)

*** Significant at the 0.001 level (2-tailed)

** Significant at the 0.01 level (2-tailed)

* Significant at the 0.05 level (2-tailed)

Table 7.2: Correlation matrix Study III, Sound Set I (n = 128). *Gamma* coefficients between all questionnaire items.

	S1:	E1:	E2:	E3:	E4:	E5:	E6:	E7:
S1: Proficiency	-							
E1: Process	0.122	-						
E2: Control	0.318*	0.632****	-					
E3: Connection	0.192	[0.344*]	0.295*	-				
E4: Challenge	-0.062	0.133	-0.106	0.222	-			
E5: Like	0.103	0.397**	0.333*	0.244	0.220	-		
E6: Influence	0.201	0.233	0.169	[0.644****]	-0.001	0.306*	-	
E7: Recommend	0.094	0.516***	0.569***	0.197	0.179	[0.579****]	0.282*	-

**** Significant at the 0.0001 level (2-tailed)

*** Significant at the 0.001 level (2-tailed)

** Significant at the 0.01 level (2-tailed)

* Significant at the 0.05 level (2-tailed)

Table 7.3: Correlation matrix Study III, Sound Set II (n = 93). *Gamma* coefficients between all questionnaire items.

Overall visual inspection shows differences in both number and strength of indicated associations between Table 7.2 and 7.3. However, the previous finding that the different sound sets had only minor influence on the individual item responses, as illustrated in Figure 7.4, raises the question as to what extent these differences are likely to be caused by other factors, such as playing environment and conditions. The degree of crowding and ‘bustle’, level of background noise and interference, and level of intoxication of player was not the same at the different times of the day that the sound sets were used (see p. 141). While this question could be further examined with more extensive statistical techniques (e.g. ordinal logistic regression) with additional data, this differentiation is be-

yond the data available and chosen method. This limitation will be discussed in detail later (pp. 182-182).

Despite this ambiguity, the two data sets will be analysed separately, as the results are considered suitable to support the method's main purpose – to examine *tendencies* of associations (see p. 100). However, no reason will be offered as to what the underlying causes for the differences between the two data sets are. The overall tendencies of association across all three studies are presented and discussed in Chapter 8.

When assessing the aspect of perceived control (E2), the data shows significant associations between 'feeling in control' and 'feeling part of a creative process' (E2/E1, Sound Set I: $\gamma = 0.32$, $p < 0.01$; Sound Set II: $\gamma = 0.63$, $p < 0.0001$), 'feeling in control' and 'like the created music' (E2/E5, Sound Set I: $\gamma = 0.32$, $p < 0.01$; Sound Set II: $\gamma = 0.33$, $p < 0.05$), and 'feeling in control' and 'feeling connected to other players' (E2/E3, Sound Set I: $\gamma = 0.27$, $p < 0.05$; Sound Set II: $\gamma = 0.30$, $p < 0.05$). With the exception of 'feeling in control' and 'recommend playing to friends' (E2/E7, Sound Set I: no association; Sound Set II: $\gamma = 0.57$, $p < 0.001$), the items associated with perceived control (E2) are identical to Study I and II for both sound sets. In summary, the results indicate an association between the players' perceived control (E2) and their sense of participation (E1, E3) and satisfaction with the outcome (E5).

7.4.2 System Interactions

During the three days of the study, *Polymetros* showed a strong appeal for festival-goers. All three instruments were occupied for most of the time, and players were usually closely surrounded by a group of onlookers, similar to observations made in Study I and II. In addition, sometimes more people were gathered loosely around this 'inner circle' of players and close spectators, extending the social radius around the installation. This 'outer circle' comprised newly arrived visitors waiting for a chance to approach the installation (e.g.



Figure 7.5: Polymetros at the Sónar 2013, Barcelona

if a player or onlooker left the ‘inner circle’). Also previous participants and bystanders (e.g. waiting for a friend to finish playing) passing their time by socialising, chatting, taking pictures or using their mobile phone, only partially focused on the installation. These different levels of focus and activity resembled the ‘activity spaces’ as used by Brignull and Rogers (2003) to describe the flow of audience interactions around large public displays, as reviewed in detail earlier (see pp. 30-34).

Interface Interaction

In contrast to Study I and II, it was conspicuous that many participants accompanied their playing with physical movement and gestures. These ranged from head nodding and foot tapping to more extensive dance moves and included ‘performative’ actions and postures reminiscent of DJs or electronic music performers. This was observed for both sound sets. Performative actions refer to expressive gestures that ‘amplify’ the dramatic effect of a small-scale action. Studying the body movements of traditional musicians, Jensenius et al. (2009) refer to such movements as ‘sound-facilitating’ or ‘ancillary’ gestures if they are directly related to sound-producing actions, and as ‘sound-accompanying’ if

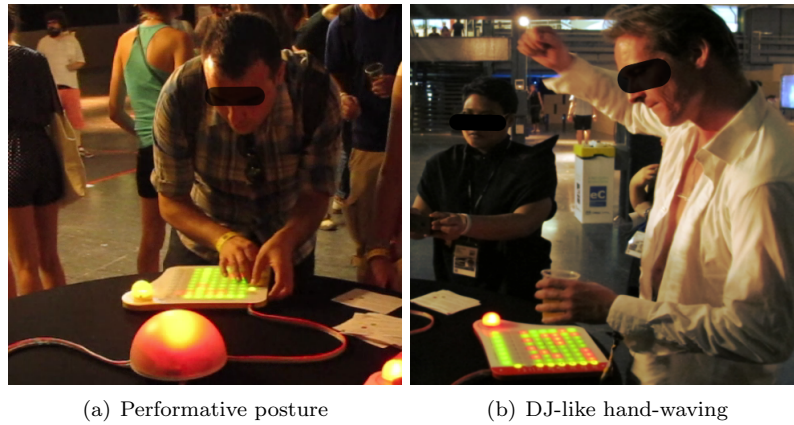


Figure 7.6: Examples of audience interactions

they follow the music on a more general level (e.g. head nodding or dancing). Observed examples include exaggerated hand and arm movements when pressing or releasing a button (e.g. ‘mute’), and whole arm or body movements when turning the Sound Dial. In one instance, a player released the drum instrument’s spring-loaded dial (low-pass filter effect) with a large-scale ‘retraction’ gesture of his arm when dramatically bringing back the ‘filtered out’ beat. In addition, several players were observed to adopt a dynamic, ‘performative’ body posture (bent forward over instrument, moving to the beat) or striking common poses (e.g. DJ-like hand-waving) towards their friends (see Figure 7.6). The style of gestures and bodily actions was similar to that observed by Xambó et al. (2013) amongst tech-savvy musicians improvising with a musical tabletop in a laboratory setting. In general, these performative interactions appeared to be closely informed by the audience’s knowledge of typical interaction and performance styles in electronic music culture, either based on frequent observation or their own experience with music equipment.

It is interesting to note that whilst the use of the Sound Dials appeared to be self-evident for some players, and associated with performative actions, other players were observed to have difficulties in understanding their purpose, as previously found in Study II (p. 127). A number of instances (11 of 40) showed participants’ unsuccessful attempts to understand the dial’s function, either by

nudging it slightly (no salient effect) or trying to press it like a button.

In general, therefore, observations suggest that players were much more likely to pick up on this feature if they were already familiar with the concept of using a knob or dial for ‘artistic’ purposes (e.g. the equaliser of a DJ mixer, or filter section of a synthesiser). Overall, average dial usage (percentage of modified notes per instance) was considerably higher than in Study II (Sound Set I: 21%, Sound Set II: 22% vs. Study II: 6%), and many participants used the dials extensively during their play. This is in keeping with the questionnaire results that a considerable percentage of respondents had experience in technology-based music-making (see p. 145).

In summary, the interaction styles observed included gestures, performative attitudes and body movements. They illustrate how the audience’s interaction assimilated the situated and socio-cultural context of the electronic music event the installation was embedded in.

Input Strategies

In addition to the performative aspects of Sound Dial use, as described above, observations indicated that the dials were also used for ‘strategic’ reasons. In several instances (6 of 40) players held the Sound Dial in its positive end position to obtain its maximum effect over longer periods (from several seconds up to two minutes), while they continued editing their pattern with their other hand. It appeared that they purposefully used the effect to make their instrument ‘stand out’ for a prolonged period by maintaining its distinctiveness (e.g. by being brighter or more resonant than the other instruments). Players that used the dial more variably (repeatedly turning from positive to negative positions) were also observed to keep holding it in its (primarily positive) end position in order to sustain its maximum effect on the sound. Both approaches are illustrated by the playing data visualisations in Figure 7.7. User 15 holds the dial in its positive end position over a long period, User 97 varies and holds it alternately. A detailed analysis of position data for the dials confirmed that this observed

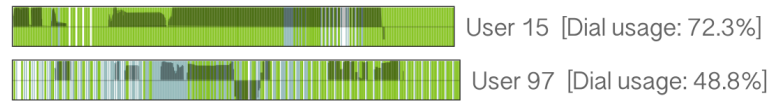


Figure 7.7: Dial usage visualisation for two instances.

interactional tendency generalised across all recorded instances of playing ($n = 221$). For both sound sets, approximately one third of the overall dial usage relates to the dial being held in its maximum positive position.

Due to the different mode of operation of the drum instrument, as used of Sound Set II, the findings related to the musical material created are reported in two separate sections. The first section refers to all instrument that were set up to create monophonic melody patterns (Sound Set I: all instruments; Sound Set II: Instrument 2 and 3). The second section refers to the drum instrument, which allowed players to create polyphonic drum patterns (Sound Set II: Instrument 1).

Melody Instruments: As seen in Study I and II, players were commonly observed to organise their patterns into closed musical figures (17 of 30 instances for melody instruments). To recap, closed figures refer to continuous, horizontal or diagonal sequences of notes as described in Study I (p. 106; Figures 5.4 and 5.5(a)). This observation was confirmed by the results of data analysis across all recorded melody instances for both sound sets, as shown in Figures 7.8 and 7.9. In both sound sets around 47% of the musical material created was organised in accordance with the characteristics of closed musical figures.

As with Study I and II, this preference appeared to be closely related to the fact that these figures were easier to recognise and distinguish from the other instruments in the overall musical output. This was supported by the fact that closed figures were commonly used when participants explained the instrument to others, in order to emphasise which part of the music came from *their* instrument, as described in Study I (pp. 108-110) and Study II (p. 129).

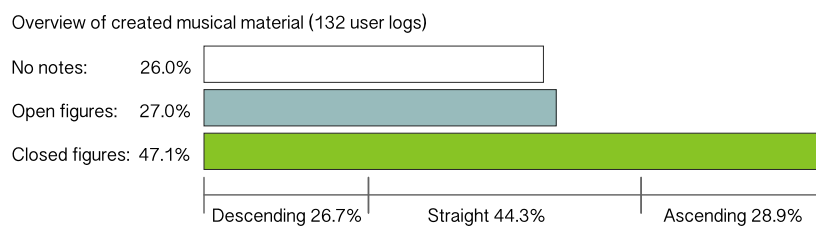


Figure 7.8: Sound Set I: Percentages of occurrence of each pattern category across all recorded instances of playing ($n = 132$).

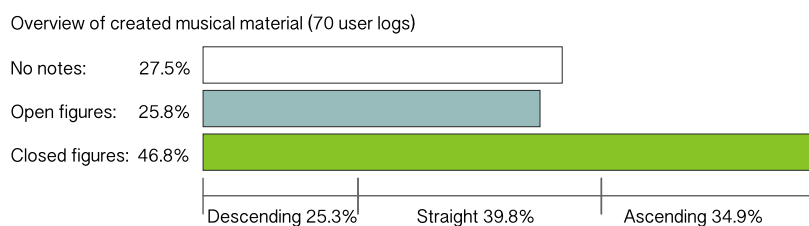


Figure 7.9: Sound Set II: Percentages of occurrence of each pattern category across all recorded instances at instrument 2 and 3 ($n = 70$).

As for Study II, the data sets matched to completed questionnaires did not indicate a direct association between the extent to which players used closed musical figures and their reported level of control (unlike in Study I). This may be because many of the more tech-savvy participants were already familiar with the note grid concept as used in a variety of music production applications. However, the frequent use of closed musical figures, in particular in the process of explaining the instrument to others, highlights their importance of their role in conveying control over the instrument.

The results of the pattern analysis for both sound sets, as depicted in Figure 7.8 and 7.9, show a strong similarity. This finding suggest that the different sound sets had no significant influence on the structure of the created melody patterns.

Drum Instrument: As described earlier (p. 69), the drum instrument allows players to create polyphonic drum patterns, with each button row mapped to a different drum sound (see Figure 3.5). While some participants appeared to be

immediately familiar with the concept, others were observed to work it out over a period of time. In several instances (4 of 10 for drum instrument), players were observed to create typical dance music drum patterns, in a determined and structured manner. For example, Figure 7.10(a) shows a player who has successively built up a generic drum beat consisting of a 4/4 kick, two off-beat snare drums, and an off-beat open hi-hat pattern.

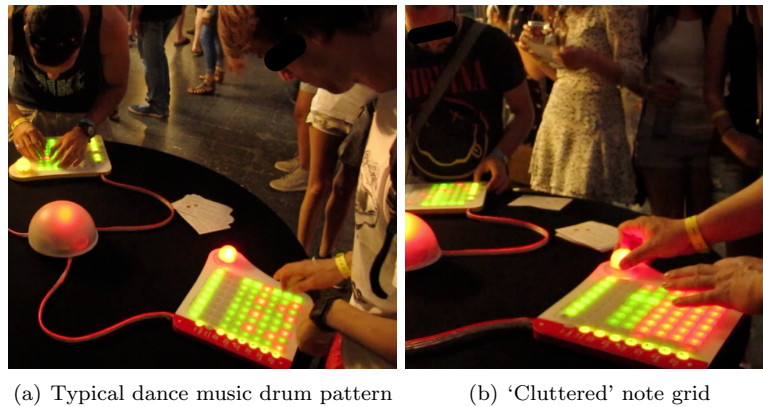


Figure 7.10: Drum instrument

However, it appeared that the different interface concept of the drum instrument was more prone to misunderstanding when trying to figure it out by ‘trial-and-error’. Players’ explorative input often led to the grid being ‘cluttered’ with notes which made it increasingly difficult to isolate the effect of their input, and as a result, harder to understand the principle of interaction. In the light of these findings, the melody instruments’ constraint of only allowing a single note input per step emerges as a clear advantage.

However, some players also seemed to ‘clutter up’ their grid on purpose. Figure 7.10(b) shows a player who has set all available notes (drum hits) on four rows and holds the dial in its positive end position (prolonging drum decay) in order to, as it appears, maximise his instrument’s loudness and dominance in the overall music.

A more general implication of providing interfaces with different functionality in a public multi-user installation is that it may mislead participants (active or

spectating) who are attempting to learn by watching other players. However, the instrument's distinct difference in sound and musical function appeared to motivate several participants, after having played on a melody instrument, to stay in order to try out the drum instrument as well.

In conclusion, the findings suggest that, given the study's context and the audience's affinity for music technology, the drum instrument was a suitable alternative, but is less appropriate for wide audiences and generally more difficult to understand.

In summary, as found in the previous studies, the observed input strategies appear to be closely related to the participants' effort to make their playing more easily recognisable and distinguishable from the other instruments.

7.4.3 Social Interactions

Forms of Participation

In contrast to the museum and exhibition setting of Study I and II, where companions and acquainted groups of visitors were typically arriving and moving on together, visitors' social formations were more fluid in the mixed-use environment of the festival (described p. 139). In general, companions and groups of friends seemed to roam loosely through the Market Lab area, dispersing and reassembling casually. Therefore, players were often joined by companions arriving at the installation at a later point in time (cf. Marshall et al., 2011). In addition, players were observed to leave their friends behind for a while (e.g. to fetch drinks, or to chat to someone in the wider vicinity), and then return to the installation. As a result, there was a higher variability in social configurations among participants, with players dropping out and rejoining, switching instruments, or repeatedly realigning themselves with friends on different instruments for co-participation. An example from the video footage that aptly illustrates these dynamics shows a group of three players who, over the course of half an hour, dynamically reorganise themselves around the installation (Appendix C.5,

Instance 20). The three friends repeatedly switch between co-participation on one instrument and playing on individual instruments, sometimes occupying the whole installation, sometimes mixed with other audience members. During the instance, two of them leave the installation (at different times), and then return and join in again.

Despite this higher overall variability, co-participation on a single instrument remained a common configuration, especially among newly arrived audience members, and was frequently observed in the annotated instances (32 of 40). As in the previous studies, such co-participation was often devoted to figuring out the instrument, either through joint exploration or in a teacher-apprentice configuration as described in Study I (p. 109) led by an experienced or tech-savvy member of the group (cf. Peltonen et al., 2008). Co-participants were also observed to coordinate their interaction by taking over different tasks. For example, in several instances (5 of 32) one participant edited the pattern while the other operated the Sound Dial.

Co-participation on one instrument was frequently followed by group members taking over individual instruments. In doing so, groups of friends often *gradually* distributed themselves across two, or all three instruments. Hence, more often than observed in the previous studies, players at different instruments were acquainted with each other. This also resulted in a higher degree of active engagement between ‘instrumentalists’ as companions often kept in touch across the table. In such configurations, participants were observed to engage in lively discussion, ask for mutual advice, or demonstrate particular actions or features to each other, either on their own instrument or by intervening in their companion’s playing. In one instance, a player reached out across the table to alternately turn the dial on his and his friend’s instrument in order to compare their effects in different positions. Participants were also observed to selectively listen to their companions’ instruments or comment on musical roles (e.g. “He [another player] is the bass.”).



Figure 7.11: Co-participation and player configurations

Figure 7.11 shows an exemplar episode that illustrates typical participatory aspects and the variation of players' configurations over time. The sequence was extracted from the additional video material taken by the research assistant, which allowed for 'zooming in' (e.g. frame 2) due to its higher quality.

A woman (P74) and a man (P75) are co-participating on one instrument. P75 demonstrates the Sound Dial to P74, which he has used extensively before (frame 1). Twenty seconds later (frame 2), P74 and P75 are playing jointly; while P75 controls the Sound Dial with one hand and switches the tempo back and forth with the other, P74 is editing the pattern. One minute later (frame 3),

P74 has taken over an instrument on her own. A man (P76), who is acquainted with P74 and P75 and previously played at P74's instrument, stands close to the table between P75 and P77, a player who is not connected to the group. In frame 4, P76 reaches across the table and switches P74's instrument into a lower octave and the sound changes accordingly into a typical 'synth bass'. As soon as P77 leaves, P76 takes her position and the group has taken over all three instruments (frame 5).

In keeping with the findings of the previous studies, active engagement between players was mainly restricted to people who knew each other. However, several situations were observed where participants proactively made contact with strangers. In one instance, a young woman at the drum instrument addressed an apparently unacquainted player next to her to signal to him that she was in charge of the beat. A number of instances (4 of 40) showed players explaining their instrument to strangers. In one case a player was approached by an unacquainted bystander ("How to play this?"), in the other three instances participants took on the ambassador role (see p. 110) by actively inviting an onlooker to join in, explaining the instrument to them in detail before handing it over.

In summary, the findings indicate that the festival environment led to a higher variation in participant configurations, and once again highlight the important role of co-participation in a public multi-user setting.

Dwell Time in Context

As defined in Study I (p. 112), dwell time is the duration that a participant actively interacts with one of the instruments. Averaged over all recorded interaction logs ($n = 221$), the dwell time was 3.3 minutes ($SD = 2.2$). Separated by sound set, the average dwell time for Sound Set I ($n = 132$) was 3.1 minutes ($SD = 2.2$), and for Sound Set II ($n = 89$) was 3.5 minutes ($SD = 2.4$). However, as for the results of the bivariate analysis discussed earlier (p. 148), determining the extent to which this difference was an effect of the different sound sets, or the variations in playing conditions and environment, is not feasible.

In order to examine if the participants' dwell time was associated with how they rated their experience in the questionnaire, Kendall's *tau* coefficients were calculated between the players' dwell time and their experience-related item responses (E1-E7) and musical proficiency (S1) in the matched data sets (see Table 7.1). Surprisingly, in contrast to Study I and II, significant correlations were found: For Sound Set I ($n = 41$), there was a significant association between dwell time and 'feeling in control' (E2) ($\tau = 0.29$, $p < 0.05$). For Sound Set II ($n = 33$), there was a significant association between dwell time and 'recommend playing to friends' (E7) ($\tau = 0.28$, $p < 0.05$). Further examination to separate potential influencing factors (e.g. sound sets vs. external factors) would demand a multivariate analysis approach, requiring additional data beyond the collected data set. Moreover, the sample size of the matched data subsets was relatively small. Nevertheless, this finding prompts the question why, in contrast to the previous studies, the rating of these experienced aspects ('perceived control' (E2), 'overall satisfaction' (E7)) might be directly related to how long the respondents chose to actively interact with the installation. Informed by the findings of the video analysis, a possible explanation relates to a difference in social etiquette between established art exhibition settings as in Study I and II and the music festival setting. Findings in the previous studies suggested that players were likely to leave their instrument in order to accommodate observing (and so potentially waiting) audience members (p. 113; p. 134). Participants at Sónar appeared to be generally less affected by this sort of social pressure. This may relate to the fact that festival goers in general experience more waiting situations. Examples are admittance to the venue, entrance to specific areas, bar tokens, food and drink, toilets and shuttle services. Therefore they might be less willing to give up their position, once acquired. Hence, despite other observed social factors to quit (e.g. companion insists on leaving), this might increase the likelihood that participants' dwell time is more directly related to how they experience (and rate) certain aspects of their interaction. However, it is important to underline that associations were only found in the two specific

cases as described above.

7.5 Reflective Summary

This section summarises the main findings of the third case study conducted to pursue the central research goals of this thesis (see p. 17). Due to the more music and technology savvy audience, it was of interest how these factors influenced their interaction with the installation. There was also opportunity to study *Polymetros* with two different sound sets. Note that overall analysis and discussion of all three studies are provided in Chapter 8, along with an assessment of the evaluation approach and implications for design.

Social and Contextual Aspects: In the festival context, there was a close circle of players and nearby spectators around the installation, as found in the previous two studies. However, this was widened by a larger peripheral audience composed of passers-by who would gradually approach, groups who had spotted one of their friends amongst the players, and people who had played already and hung around; socialising, waiting for friends to finish, or eventually rejoining the players. These different stages of engagement or ‘activity spaces’ (Brignull and Rogers, 2003) relate to Sheridan and Bryan-Kinns’s (2008) work on performative interactives in festival settings, which describes the transitional process from unwitting bystander to audience, and on to active participant. In this study, observations showed that these different stages were crossed fluently and bidirectionally. In line with the more dynamic surroundings, there was also a higher variability in social configurations during active participation, with participants switching between their co-players or instruments. Nevertheless, co-participation on a single instrument remained a common configuration. This was often followed by members of a group moving on to other individual instruments and gradually taking over the installation. This also led to a higher level of active engagement between players on different instruments (e.g. discussion and mutual intervention) as friends and former co-participants often kept

in touch across the table. Surprisingly, in contrast to Study I and II, significant correlations were found between players' dwell time and how they rated their experience in the questionnaire. However, as a more detailed examination of this result was beyond the limits of the chosen method (as discussed later, pp.182-182), and only two association pairs were found, this indication was merely used as an impetus to reflect on why a direct relation between dwell time and experience ratings may be seen in the given study context. A potentially reason was that, in contrast to Study I and II, players appeared less pressured to accommodate waiting audience members by leaving their instrument for another visitor to take over. This may have increased the likelihood that the time they spent actively engaged with the installation was more directly related to how they rated certain aspects of their playing experience.

Interactional Aspects: A characteristic feature of the audience interaction was that many participants' style of interaction reflected typical gestures and attitudes of performance and production culture in electronic music. Besides being expressed in their bodily interaction with the instruments, this knowledge also seemed to inform the understanding of interface features such as the Sound Dials. While in general dial usage was considerably higher than in Study II, the observations indicated that this was largely due to prior experience rather than more successful exploration attempts of participants who were less familiar with using a dial for creative sound control. This also ties in with the questionnaire finding that a significant percentage of respondents had experience in technology-based music making. In addition, players also appeared to purposefully use the dials to make their instrument 'stand out' and more easily recognisable in the overall music. This was supported by data analysis showing that the related, commonly observed strategy of holding the dial in its maximum position generalised across all recorded playing data. Closed musical figures were a popular input strategy, and, as in previous studies, this preference seemed closely related to the fact that these simple patterns were easier

to identify and follow in the collaboratively created music. Interestingly, data analysis suggested that the different sound sets had no significant influence on the structure of the created melody patterns. Moreover, it was found that participants' rating of their experience in the questionnaire was hardly effected by the alternative sound sets.

While suitable for music tech savvy users, the drum instrument appeared more difficult to understand. More generally, the findings indicated that providing similar looking interfaces with different functionality might hinder people in their common attempts to learn by watching others. Interestingly, in the same way that some players used musical figures or common 'dial holds', others appeared to use the instrument's polyphony to make their sound stand out, purposefully setting many notes to play at the same time to make the output as loud as possible.

Finally, despite indicating some limitations of the applied method for in-situ studies (as discussed later, pp. 182-182), the results indicated associations between player's perceived control and their sense of participation and satisfaction with the outcome. In keeping with the findings from Study I and II, this strengthens the evidence that, in collaborative musical experiences, participants' perceived level of control is related to their enjoyment and their sense of feeling part of a creative process.

Chapter 8

Discussion and Implications

This chapter draws together the findings of the three studies presented in Chapters 5-7, in order to reflect more broadly on how they can inform and contribute to design and research around collaborative music and technology-mediated public creativity.

First, the results of all three studies are compared to examine the research goals in the light of the overall findings. In addition, characteristic differences between the studies are identified and discussed, with respect to how they relate to the different contexts of the three audience evaluations. Next, several design implications for public collaborative musical environments are proposed, and general implications for technology-mediated public creativity are discussed. Finally, the mixed-methods evaluation approach devised to address the research goals, and adapted throughout the research process, is discussed and evaluated.

8.1 Comparison of Studies

This section gives a consolidated account of the main research outcomes by providing a comparative overview of the findings of all three studies while highlighting similarities and differences.

8.1.1 Questionnaire Results

Questionnaire Responses: Figure 8.1 shows the responses to the experience-related items (E1-E7) for all four conditions studied (Study I; Study II; Study III: Sound Set I; Study III: Sound Set II). Each statement is represented as a combined bar graph showing the corresponding responses in percentages. To enable direct comparison, the bar graphs are normalised respectively to the sample size of the corresponding data set.

An overall distinctive feature is that for all items the general tendency of responses is very similar across all four study settings.

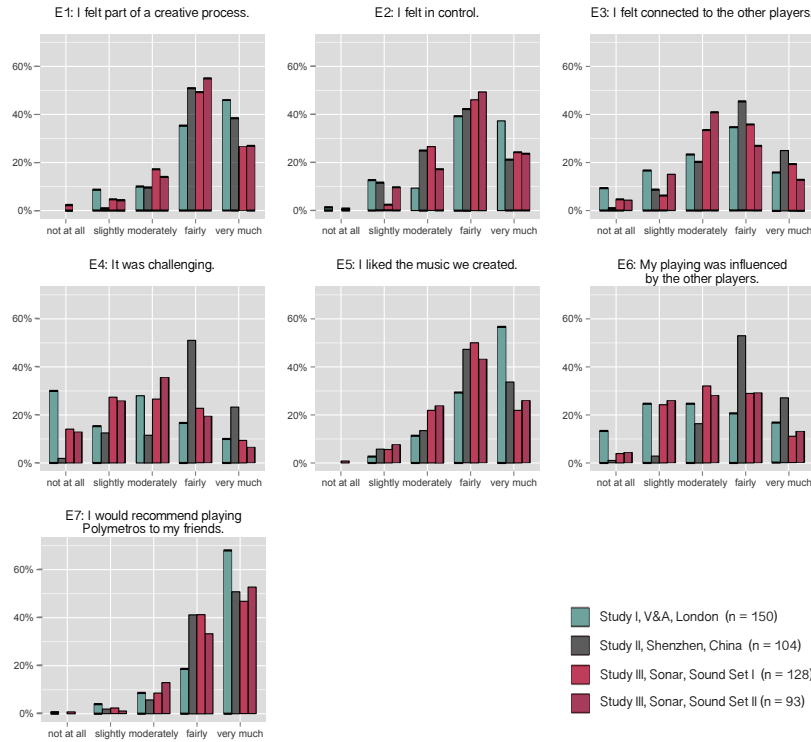


Figure 8.1: Comparison of questionnaire results. Survey items represented as combined bar graphs showing the corresponding responses in percentages for all four conditions studied: Study I, II, and III (with two different sound sets).

E1: I felt part of a creative process. E1 received high ratings across all four conditions with an overall response pattern skewed around *fairly* towards *very much*.

E2: I felt in control. E2 was rated fairly high across all four conditions with a central tendency around *fairly*.

E3: I felt connected to the other players. E3 received moderate to high ratings across all four conditions with a central tendency around *moderately/fairly*.

E4: It was challenging. Along with E6, E4 shows the greatest variability in responses across all response categories with a prominent ‘outlier’ (*fairly*) from Study II (China). This might be related to the generally more inexperienced audience. A second, less distinct ‘outlier’ (*not at all*) belongs to Study I (V&A). A potential reason could be that, in contrast to the other studies, at times there were two members of the research team present to provide initial guidance.

E5: I liked the music we created. E5 was rated fairly high across all four conditions with a central tendency around *fairly*, with a positive outlier from Study I (*very much*).

E6: My playing was influenced by the other players. Along with E4, E6 shows the greatest variation of responses across all response categories with a salient ‘outlier’ (*fairly*) from Study II (China). A potential explanation could be that the generally less experienced participants oriented themselves more towards other players while figuring out the instrument.

E7: I would recommend playing Polymetros to my friends. E7 received the highest ratings across all four conditions with an overall response pattern skewed towards *very much*.

In summary, the comparison highlights that across all four conditions the ratings show common tendencies towards a sense of creative participation (E1, E3), enjoyment (E5, E7) and control (E2), whilst perceived challenge (E4) and the influence of others (E6) were rated more diversely.

Bivariate Analysis: In the chapters related to specific studies, the bivariate analysis was primarily focused on examining the aspect of perceived control, as one of the main research interests. This section provides a comparative overview

of the overall association tendencies between all questionnaire items across all four conditions studied. This overview is presented in Figure 8.2. As the focus is on visualising the overall *trends* of associations across all four conditions, the correlation coefficients of individual pairs are omitted for reasons of clarity. These can be found in the respective correlation matrices (p. 101, 125, and 148).

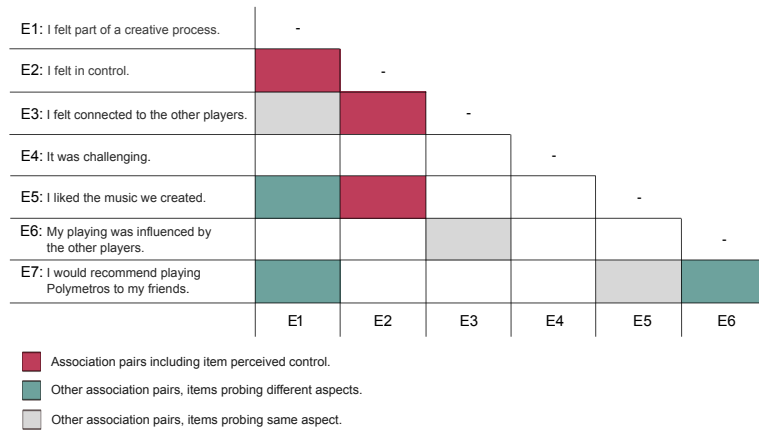


Figure 8.2: Overall trends of association. Coloured fields indicate significant correlations of corresponding items in all four studied conditions: Study I, II, and III (with two different sound sets).

In Figure 8.2, a field that is coloured indicates that there was a significant correlation between the corresponding questionnaire items in all four studied conditions. The different colours will be used to structure the discussion of the results. *Red* marks pairs of items that involve perceived control (E2), while the other colours separate the remaining pairs between items that probe the same aspect (*Grey*) and those that probe different aspects (*Teal*). To recap, the seven experience-related questionnaire statements were designed to gauge three main aspects (see p. 96); 1) sense of participation (E1, E3, E6), 2) sense of control and challenge (E2, E4), and 3) satisfaction with the playing experience (E5, E7). Therefore, the correlations marked in grey are not particularly surprising, instead confirming that the chosen items were actually successful in probing the same general aspect. Hence, the following section discusses the remaining six pairs, which are listed in Table 8.1.

Focusing on the aspect of perceived control (E2) first, the overview shows that across all four studied conditions there were significant correlations between ‘feeling in control’ (E2) and ‘feeling part of a creative process’ (E1), ‘feeling in control’ (E2) and ‘feeling connected to others’ (E3), and ‘feeling in control’ (E2) and ‘like the created music’ (E5). This overall examination highlights the association of perceived control and sense of participation (E1, E3) and satisfaction with the outcome (E5). Most importantly, the fact that these associations occurred under all four conditions, despite different exhibition settings and socio-cultural contexts, strengthens the empirical evidence that participants’ sense of control is related to other perceived qualities in collaborative musical experiences such as feeling part of a creative process.

The other pairs of association that were found to be significant in all four studied conditions were ‘feeling part of creative process’ (E1) and ‘like the created music’ (E5), ‘feeling part of creative process’ (E1) and ‘recommend playing to others’ (E7), and ‘playing influenced by others’ (E6) and recommend playing to friends’ (E7). These findings indicate that feeling part of a creative process is positively associated with being satisfied with outcome (E5) and the overall experience (E7). Moreover, they suggest that experiencing mutual influence and interaction (E6) is also positively related to participants’ overall satisfaction (E7).

1. E2/E1:	‘feeling in control’ / ‘feeling part of creative process’
2. E2/E3:	‘feeling in control’ / ‘feeling connected to others’
3. E2/E5:	‘feeling in control’ / ‘like the created music’
4. E1/E5:	‘feeling part of creative process’ / ‘like the created music’
5. E1/E7:	‘feeling part of creative process’ / ‘recommend playing to friends’
6. E6/E7:	‘playing influenced by others’ / ‘recommend playing to friends’

Table 8.1: Overview of item pairs that were significantly associated in all four studied conditions.

In summary, this set of associations emerged from four different study conditions, including different situated and socio-cultural contexts, with 475 respondents in total. Therefore, this is likely to represent more general tendencies,

and so contribute to the understanding of collaborative public creativity, and inform related design choices as discussed in Section 8.2.

8.1.2 Social Interactions in Context

This section summarises the main findings on social interaction and participatory audience behaviour across all three studies. The overview is structured according to the three phases of approaching, interacting with, and leaving the installation.

Approaching: In all three studies it was observed that before joining in, audience members would engage with *Polymetros* by watching active participants, typically trying to form an initial understanding of how it worked. In doing so, audience members usually proceeded stepwise **from focused observation to active participation** (cf. Michelis and Müller, 2011). In the more traditional exhibition settings of Study I and II, these zones of gradual engagement (cf. Brignull and Rogers, 2003) were closely concentrated around the installation. In the festival setting of Study III, this ‘inner circle’ of players and focused spectators was extended by a larger peripheral audience. This encompassed as yet unwitting bystanders (Sheridan and Bryan-Kinns, 2008) and audience members who were only partly focused on the installation while socialising with others. This wider social radius around the artwork was related to the more loose and fluid social formations of visitors in the festival environment. This contrasts with the museum settings of Study I and II, where audience members who were acquainted with each other typically arrived and moved on to the next exhibit together.

In contrast to Study I (UK) and Study III (Spain), the Chinese audience in Study II were slightly more hesitant in approaching the installation, and more tentative in applying a trial-and-error strategy to figure out the instrument. It appeared likely that this tendency was related to many visitors’ unfamiliarity with public interactive installations, which is in keeping with the fact that the

Chinese audience rated the playing experience as most the challenging amongst all three study audiences.

Interacting: In all three studies the most common social configuration of audience interaction with the installation was **co-participation**, where acquainted audience members participated together **by sharing one instrument**. Co-participation was typically characterised by an initial attempt to figure out the instrument collaboratively, either through joint exploration or in a teacher-apprentice configuration led by one of the participants (cf. Peltonen et al., 2008). This illustrates that the process of engagement with the installation - as described by Bilda et al. (2008) as a “transformative dialogue between the participant and the art system” - evolves in multi-user situations to a significant extent *amongst* participants, especially in the early stages of ‘anticipation’ and ‘learning’. Co-participants were also observed to coordinate their joint playing by either editing in turn, or by simultaneously controlling different functions. Hence, co-participation was a highly collaborative form of participation. Despite the fact that when visitor numbers were high, often only one of the three instruments was available, co-participation appeared to be generally socially motivated. It seemed to be a common strategy to manage social discomfort, or the reluctance to approach an as yet unknown device on one’s own in the presence of strangers, similar as indicated for other public interactives before (O’Hara et al., 2008; Sheridan et al., 2007; Brignull and Rogers, 2003).

For similar reasons, explicit interaction between unacquainted participants was rare, and active engagement amongst different ‘instrumentalists’ mainly occurred between audience members who knew each other. In contrast, however, the findings indicated tacit mutual awareness and adoption of action from unacquainted players. Compared to Study I and II, where co-participants often remained together for their entire period of participation, in the festival environment of Study III, initial co-participations were often followed by group

members taking over individual instruments. This led to a higher level of active engagement between players on different instruments as they knew each other already. In general, there was greater variability in social configurations in the festival setting, with players frequently switching between instruments or teaming up with different co-players.

Leaving: In general, it was found that participants' dwell time was considerably influenced by social and contextual factors. As a typical example, it was common in all three studies that participants withdrew from playing in order to follow their companions who were moving on. In particular in Study I and II, many participants appeared to feel an '**obligation to leave**' once they became aware of spectators in their direct vicinity, in order to accommodate potentially waiting audience members. This links in with the finding that the average dwell time was lower during highly frequented exhibition periods when the installation was in high demand. In the festival setting of Study III, however, participants seemed to be less affected by this type of social pressure. Yet in general, the findings illustrated how social and contextual factors influence dwell time. This was supported by the result that (apart from two potential exceptions in Study III, see p. 160) no associations were found between participants' dwell time and their experience-related questionnaire responses. This indicates that there was no direct relation between their time spent with the installation and how they rated their experience with it.

In summary, besides underlining the general fact that audience experience of interactive artworks is socially determined (e.g. vom Lehn et al., 2001), the findings in particular demonstrate *how* these social and contextual influences come into effect in all three phases of the audience's engagement with the installation.

8.1.3 System Interactions: Strategies and Motivations

This section summarises the main findings on how audiences interacted with the system and reviews the underlying motivations and objectives identified.

Input Strategies: A prominent finding across all four conditions studied was that despite the different exhibition settings and socio-cultural contexts, participants showed a common preference for creating closed musical figures (see p.106). Most importantly, in all three studies this preference seemed to be largely motivated by the fact that these figures were the easiest to recognise and follow in the collaboratively created music. This was supported by the fact that participants almost invariably used this input strategy for explaining the instruments to others, and it was generally found to be the most effective way to facilitate an understanding of how the musical interface worked. Other input strategies were identified that served the purpose of promoting recognisability by providing salient feedback (e.g. ‘dial hold’ in Study III, p.152). In general, this indicates that **players’ input was considerably driven by attempts to gain and maintain clear recognisability** of their musical contribution. This finding strongly supports the central argument of this thesis that in order to successfully facilitate collaborative musical experiences, it is vital to provide each participant with effective mechanisms that support individual control and recognition of what they contribute to the co-created music.

Audience Experience and Interaction: Morrison et al. (2007) found that the written and verbal feedback provided by participants of interactive art installations was substantially influenced by their pre-disposition and experience. This tendency was noticeable from the responses gathered e.g. when comparing descriptions of museum audiences (e.g. “it’s like a family game”, “it’s a Brian Eno machine”) with the ones given at the Sónar Festival, which often had a more technical flavour (e.g. “it’s similar to Yamaha’s Tenori-On”). In addition, the studies demonstrated how **participants’ experience influ-**

enced their interaction with the system. In Study II (China), the newly introduced Sound Dials were not intuitively understood, which led to low overall usage. By contrast, in Study III, where a considerable percentage of participants indicated that they were familiar with music technology, the dial usage was significantly higher. Also, players' performative attitudes in Study III were reminiscent of typical gestures and interaction styles from electronic music culture, illustrating this interrelation between disposition and interaction.

Interaction and Mutual Influence: Whilst explicit interaction (e.g. verbal) between unacquainted players rarely occurred (see p. 170), the studies showed how mutual awareness amongst participants informed their interaction with the system. Participants were found to adopt input strategies and playing techniques from other players. These included single actions (e.g. dial turn), as well as more complex interactions combining the use of several functions. In keeping with the general finding that exhibition visitors are “sensitive to the presence of others and in various ways monitor each others' actions and activities” (vom Lehn et al., 2001), the studies explicitly show that in a dedicated multi-user configuration **mutual observations lead to active exchanges of action between unacquainted participants.** Interestingly, these findings are similar to the ‘mimicking’ of actions found amongst expert musicians in a laboratory study with a musical tabletop (Xambó et al., 2013). It may be that these tacit mutual interactions between unacquainted players contributed to participants' perceived connectedness and sense of creative participation, as reflected in the questionnaire results.

In summary, the overall preference for most clearly perceptible input strategies highlights the importance of fostering individual control and identifiability of contributions in collaborative musical experiences. In addition, it was shown that participants' system interactions were influenced by other players and were considerably informed by their own personal experience.

8.2 Design Implications for Collaborative Musical Experiences

This section presents three general implications for designing Interactive Collaborative Musical Experiences for public settings, synthesised from the main research findings of this thesis. Each design implication is complemented with a set of related considerations that are discussed in the following section. In summary these implications are:

- Foster Individual Control and Recognisability
 - Balance Individual Contributions and Co-created Outcome
 - Balance Depth of Interactivity and Level of Facilitation
- Support Co-participation in Multi-User Settings
 - Consider Physical and Spatial Layout
 - Allow for Shared Visibility of Action
 - Provide Shared Input Capabilities
- Provide Visibility of Action for Participants and Audience
 - Attract Passers-by
 - Support Observational Learning
 - Foster Exchange of Action

8.2.1 Foster Individual Control and Recognisability

As discussed previously, all three studies have shown that in the multi-user setting provided, participants strived to affirm their individual control by applying playing strategies that let them easily identify *their* contribution to the co-created music. Moreover, the finding that participants perceived level of control was directly related to their feeling of being part of a creative social process emphasised the importance of fostering mechanisms for individual control and recognisability, in order to successfully facilitate collaborative musical experiences. However, this overall design goal can only be approached by carefully balancing the interdependencies between individual contributions and overall musical outcome, as well as between the depth of interactivity offered and the level of facilitation provided.

Balancing Individual Contributions and Co-created Outcome: In the musical multiplayer setting, participants' individual contributions can not be emphasised independently without affecting others. For example, if one instrument has a generally more assertive sound than the others, this benefits its player through easier recognisability, but disadvantages the others by masking their contributions to a greater extent. Therefore, a balance has to be found between supporting individual control and recognisability and distributing it equally among all participants. At the same time, these individual contributions should harmonise in such a way that they co-compose the outcome of the social and creative musical experience.

In the case of *Polymetros* this balance was approached by adapting the principle of musical minimalism in order to achieve an interesting overall outcome based on simple individual contributions, hand-in-hand with the design and careful adjustment of interactive and sonic properties. In particular, much time and testing went into the process of 'tuning' the sound characteristics as described in detail earlier (pp. 62-69), including selection and adjustment (programming) of sounds, their parametrisation (e.g. adjustable pitch range; effect of dial), and adapting playback and speaker settings. In addition, certain parameters were re-adjusted depending on the study location (e.g. how reverberant the room was) finding the best configuration through iterative testing. This illustrates that every collaborative musical experience has to be 'tuned' individually in order to strike the desired balance between individual contributions and overall outcome.

Balancing Depth of Interactivity and Level of Facilitation: Another factor to be considered is what level of interactivity is appropriate, depending on the intended mode of presentation and context of the designed experience. *Polymetros* prioritised a deep level of interactivity in order to foster participants' individual sense of control through access to music's basic elements (pitch, rhythm, timbre), and to provide multiple possibilities for exploration,

informed by links found between exploratory user behaviour and perceived creativity (Ghani, 1995; Ghani and Deshpade, 1994). As a result of accounts of how public musical multi-user installations were negatively affected by a lack of initial guidance (their originators felt urged to introduce some level of facilitation subsequently, see *Understandability and User Experience*, pp. 39-39), it was decided from the outset to offer initial guidance to participants, to allow for a deep level of interactivity. In general, the high interactivity was found to act as a *sustainer* (see p.27) maintaining the engagement of many participants by offering various opportunities for further exploration, once they had gained an initial, basic understanding.

However, in other contexts – e.g. when designing a permanent exhibit for a museum – initial guidance by a facilitator may not be an available option. Consequently, the restriction to using signage or providing interactive support through the installation itself is likely to demand for a lower level of interactivity, along with the system’s overall complexity. In such cases it is imperative to carefully test and re-evaluate the appropriate level of interactivity to determine how it can be capitalised most effectively to foster participants’ individual sense of control, in balance with the overall co-created outcome.

8.2.2 Support Co-participation in Multi-User Settings

Co-participation on a single instance of the multi-user interface was found to be one of the most common interaction configurations, and therefore it is a key configuration to support in public multi-user experiences. Whilst admittedly not being considered specifically in the conceptual design phase of *Polymetros*, several design choices, primarily made to support participants at *different* instruments, turned out to provide beneficial conditions for co-participation. They encompassed physical, visual and interactive aspects to be considered as follows.

Physical and Spatial Layout: Physical layout and spatial configuration should allow for a single instance of the multi-user interface to be approached and attended by several participants at once. This necessity was illustrated by the fact that individual instruments were often ‘hogged’ by groups of two or more audience members (e.g. see Figure 6.4, p.126).

Shared Visibility of Action: Each instance of the multi-user interface should provide a highly visible representation of interaction to all co-participants. This requirement was particularly underlined by the fact that typical interactions amongst co-participants, such as mutual explanation, were highly dependent on a shared visual access to the illuminated LED grid. This quality would have been significantly impaired by, for example, the use of screen-based interfaces (cf. Heath et al., 2002), which only support comparably narrow viewing angles.

Shared Input Capabilities: Active collaboration on a shared user interface, as commonly observed during co-participations (e.g. simultaneously controlling different functions), advocates for multi-user input support and an interface layout that allows simultaneous access by multiple users.

8.2.3 Visibility of Action for Participants and Audience

In general, it was found that a high degree of visibility benefits a public multi-user system on several levels, most notably by attracting visitors and promoting understandability and interaction for both participants and spectators.

Attract Passers-by: In all three studies, the installation’s strong attraction for passing visitors seemed to be closely related to its high visibility in combination with its sound radiation, reinforced by the visible conduct of current participants. In keeping with findings of Sheridan and Bryan-Kinns (2008), this indicates that in public settings, wide-reaching noticeability conveyed through light, sound and action serves as a strong *attractor* (see p.27) to draw in audience members.

Support Observational Learning: The findings showed that before joining in, audience members typically engaged with the installation by observing active participants in order to learn about the system’s interactive properties. In order to support this stepwise engagement process, the interface should promote visibility of action that grants spectators (typically grouped at some distance) with visual access to system interactions.

Foster Mutual Exchange of Action: Finally, the studies showed that players used visual access to other participants’ actions as a resource to spot interactive features they had not yet discovered, and to figure out new opportunities for interaction that they then integrated into their own playing. This underlines that designing for mutual visibility of action promotes mutual awareness amongst participants, contributes to their understanding of the system, and fosters mutual exchange between contributors. Therefore, providing similar looking interfaces with different functionality (Melody Instruments vs. Drum Instruments; Study III, Sound Set II) is not advisable as it might impair the benefit of learning by spectating.

8.3 General Implications for Technology-Mediated Public Creativity

This section briefly discusses how the findings may inform other designs that aim to support collaborative public creativity but which are not themed around sound or music.

In general, the notion of a participant’s individual contribution to a co-created overall outcome is not exclusive to musical contexts. Therefore, it is reasonable to assume that the importance of fostering individual control and identifiability of contributions – as demonstrated in this thesis for a musical context – may be similarly relevant to feeling part of a collaborative process in other scenarios. Possible examples could be collaborative visual creation or digital story telling.

As discussed previously, Weinberg (2003) recognised that players felt disconnected from the creative process if their (musical) contribution was modified by peers beyond recognition – an equally negative impact could well be imagined for the process of collaborative painting or story creation. Initial indications that aspects examined in this thesis may translate to other creative domains are illustrated in the following example. Peltonen et al.’s (2008) research around public large-scale interactive displays found that people attempted to ‘leave marks’ (emphasise their contribution), or engage in conflict with others about ownership, as the system did not facilitate ways for their contributions to ‘co-exist’, or be brought into a mutual relation to ‘harmonise’ as the co-created outcome. This indicates that in other domains a core design challenge of creating collaborative experiences is also to strike the right balance between the support of individual control and sense of contribution and the overall creative outcome co-created by all participants involved.

In addition, the two further general design implications synthesised from the main findings of this thesis (see p. 174) to *Support Co-participation in Multi-User Settings*, and to *Provide Visibility of Action for Participants and Audience* seem worth considering in contexts beyond music and sound-related interaction. Both are based on observational findings that are likely to reflect patterns of general audience behaviour, rather than phenomena that are specifically linked to music. Therefore, they appear valid to be considered as general design implications for technology-mediated public creativity. This prospect is supported by the fact that, whilst these implications were directly derived from the collected data, their underlying participation patterns (e.g. co-participation or observational learning) could be related to findings on audience behaviour around non-musical public exhibits.

8.4 Discussion of Methodological Approach

The following section discusses the evaluation approach with emphasis on how the selected methods contributed to the main goals and findings of this thesis. It also reflects on practical issues and lessons learnt from the three field studies. To recap, the mixed-method approach was devised to best cater for the different research objectives of this thesis (see p. 17) whilst taking into account the implications of conducting research in real-world exhibition settings as discussed in Section 4.3.

Field Notes and Video-based Interaction Analysis: In terms of the social and context-related findings, field notes and video-based interaction analysis proved to be suitable for fostering an understanding of the situated social and system-related interactions. Applying them in a systematic and structured way enabled the identification of patterns of audience behaviour (Bilda, 2011) (e.g. the prevalence of closed musical figures), and more importantly, provided a way to understand why they were meaningful for the participants (Crabtree et al., 2000). In particular, revisiting the direct observations of large numbers of audience members, through detailed post-hoc video observations, provided confidence in the context-related findings. The fact that the investigation of social and contextual aspects was driven by observation rather than by an external analytic framework (see p.85), allowed identification of phenomena that, after emerging from the data through frequent observation, became central themes of subsequent analysis. As an example, it could not be anticipated beforehand that participants' explanation of the instrument to others would become such a relevant activity to study – as an act that provided insight into people's understanding of the instrument, and as a key aspect of co-participation, another significant phenomenon that directly emerged from the data. After having identified a core interactional aspect such as co-participation, this informed the focus of subsequent studies, in order to further pursue this phenomenon and its potential meaning in the light of a different study context. Whilst analysis was

led directly by the descriptions of the observed activities, close attention was paid *afterwards* to how the identified phenomena corresponded to comparable work on social interactions around public, non-musical interactive exhibits, in order to evaluate where the findings sat in relation to the wider research field. As an example, co-participation and the observed related social practices corresponded to reported findings that in museums, visitors often explore interactive exhibits in collaboration while discussing their actions and ‘scaffold’ each other (e.g. vom Lehn et al., 2001; Meisner et al., 2007; Hornecker and Stifter, 2006).

Interaction Data Analysis: Investigating situated technology-mediated interaction provides the possibility to additionally support observational data with data that capture the user-system interaction. Analysis highlighted the potential of this type of data to inform, support and complement contextual observations as well as other methods such as self-report measures. For example, the analysis of interaction data allowed verification that interaction patterns previously identified through observation, such as closed musical figures, tentative dial use (Study II), or ‘dial hold’ (Study III) generalised across all recorded playing data.

Importantly, this illustrates that interaction data gains its real value and meaning primarily *through* the observations. By identifying patterns of interest, it is the observations that reveal how to harness the data gathered in ways that contribute to the specific research interests. In accordance with Hornecker and Stifter (2006), this underlines that examining links between audience observations and interaction data can significantly inform the overall analysis and contribute to the validity of findings. Yet it should be noted that the development of data acquisition and analysis tools required a considerable amount of time and effort, and that the coordination and execution of data collection was a challenging aspect of the field work. However, this effort was rewarded by having a tool at hand that allowed for further examination of observational findings, testing their generalisability and significantly increasing their validity.

Questionnaire and Bivariate Analysis: The questionnaire devised proved to be an effective tool to elicit a short assessment of playing experience from large numbers of participants (hundreds), and to map out trends across the collected responses. Certain aspects, such as differentiating between respondents' general appreciation for music and their formal musical experience, were gradually improved based on the experience gained from the studies.

In general, the bivariate analysis suited its intended purpose of examining tendencies of association between questionnaire items. It significantly contributed to the research goals by providing evidence that perceived control was related to participants' enjoyment and their sense of feeling part of a creative musical process.

However, in Study III, the results highlighted some limitations of the method for in-situ application. Although it was still feasible to examine *tendencies* of association, the introduction of two different study conditions (sound sets) led to ambiguities in interpreting the results, as the method did not allow for further examination and separation of potential influential factors (e.g. sound sets vs. external factors). As noted earlier, this issue could in general be addressed with more extensive statistical techniques (e.g. ordinal logistic regression) but would likely require additional data, beyond that collected in the field studies. The practical feasibility of such an approach remains questionable, as the studies showed that the contextual factors to be taken into account in order to allow for further differentiation were generally difficult to measure (e.g. how to define and measure degree of 'bustle'). This suggests that a two-condition approach – a concept rooted in the tradition of controlled laboratory studies – is inappropriate in a 'messy', real-world environment. Unanticipated conditions can not be controlled or measured to an extent that would allow assessment of the effect of one 'independent variable'.

Practical Issues and Considerations: Whilst not being directly related to the methodology per se, an important pre-condition to successfully study

public interactivity in real-world settings is that the system is technically mature enough to do so. The exhibition settings required *Polymetros* to operate reliably over long periods, to withstand excessive input (e.g. children and visitors who ‘challenge’ the system), to be set up and dismantled in a short amount of time and to be transportable by one person. These requirements exceed the execution quality of a ‘polished’ working prototype, as sufficient for an ‘in-house’ study or in semi-public spaces such as a conference (both of which often result in the audience being mostly academics from a similar field). In addition, a high quality appearance and fidelity of the installation, along with a visual identity (name, logo, video demonstration) was an important factor in attracting the interest of curators and getting invited to exhibitions.

In general, both the methodology and its practical execution, as well as the system’s technical development for real-world use, were informed by conducting a pilot in a realistic study setting. However, the studies also illustrate that when undertaking audience evaluations in ‘messy’, real-world environments, some flexibility is needed to account for conditions that were not anticipated beforehand. In all three studies compromises had to be made, for example, not being able to conduct interviews due to the local conditions (Study I), restricted options for camera positioning (Study II, III), or accepting extreme noise interference (Study III). In general, these examples suggest that certain contingencies have to be expected and therefore advise against approaches that are over-dependent on a particular method or factor.

Conclusion: In conclusion, the three case studies demonstrate the value of adopting a mixed-method approach for evaluating technology-mediated public creativity. While the qualitative components of the studies promoted a descriptive understanding of the audience’s social and system-related interactions, the quantitative methods allowed for examining concrete research questions such as the value of perceived control in an interactive multi-user environment. Moreover, by emphasising the significant influence of the context on the participant’s

behaviour, the studies presented underline the importance of a contextual approach in order to study, understand and evaluate new interactive experiences within real-world environments.

8.5 Summary

This chapter has drawn together the results of the three studies, compared and discussed them, and presented the main findings of this thesis. Based on these findings, a series of design implications was proposed. Finally, the methodology and evaluation approach were reviewed. The following chapter concludes this thesis with a brief summary, and points out limitations and avenues for future work.

Chapter 9

Conclusion

This chapter summarises the key findings and recapitulates the contributions of this thesis. Limitations are indicated and the thesis draws to a close with potential avenues for future work.

Considering the extent to which digital technology has transformed how people consume music and broadened access to music production, there is a surprising lack of applications that explore novel forms of technology-mediated musical creativity, in particular, those that focus on co-creation and collaboration in social contexts, and reach out to broad, non-expert audiences. This form of technology-mediated, public collaborative creativity is also an understudied area in academic research.

The subject of this thesis was the study of *collaborative musical experiences*, characterised by the use of interactive technology to make the experience of musical co-creation and collaboration available to broad audiences, with a particular focus on facilitating the process of ‘making’ as a creative end in itself. This process-focused, social and participatory perspective on technology-mediated music making distinguishes this work from the majority of NIME research, which, to a large extent, follows the Digital Musical Instrument (DMI) paradigm characterised by a categorical distinction between performer (active

player) and audience (passive spectator). Therefore, particularly with regard to evaluation, this thesis has a strong leaning towards interactive art research, and has adopted this perspective for the study of interactive music systems in public settings.

Based on a comprehensive review of previous research into music systems for non-experts, this thesis investigated the value and effect of participants' individual sense of control in collaborative music-making, and developed a descriptive understanding of how people behave and interact in such multi-person environments in real-world contexts. Since there have been no previously published studies concerned with a systematic, contextual evaluation of collaborative musical experiences with large numbers of participants, this work makes a number of novel contributions to the field. Firstly, it provides empirical evidence that there is a correlation between participants' perceived level of control and their sense of creative participation and satisfaction with the outcome. Secondly, it yielded a number of empirical findings that describe and explain aspects of audience behaviour, engagement and mutual interaction around public multi-person interactives. Thirdly, based on the empirical findings, it synthesised a set of design implications to aid designers of future collaborative music systems. And finally, it has demonstrated the application of a mixed-method approach for studying technology-mediated collaborative creativity with live audiences. The following sections provide a brief synopsis of the studies and summarise the main findings. The chapter concludes with suggestions for future work.

9.1 Overview and Major Findings

To drive the research components of this thesis, a collaborative interactive music system named *Polymetros* was developed. The design was based on the findings of a thorough assessment of previous work in this area. *Polymetros* enables a group of people to collaboratively create minimalist or electronica inspired music, and is designed for public settings such as museums or festivals. Participants

can take control of one of three instruments, each of which has different sound characteristics. Users play the instruments by creating musical patterns on a loop-based, grid-style interface. Through the variable, dynamically modifiable loop length of each instrument’s pattern, their combinations create minimalist music-like evolving musical textures. Later iterations (as used in Chapter 6 and 7) also allow for modifying the instruments’ timbre, to increase sonic variety and richness.

All three studies addressed the main research goals of this thesis, as restated above, by investigating them in different exhibition settings and socio-cultural contexts. The studies were conducted at the Victoria and Albert Museum, London, UK (Study I), the ‘Design Can Change’ New Media Art Exhibition, Shenzhen, China (Study II), and the Sónar Festival 2013, Barcelona, Spain (Study III). Participants for all studies were unsolicited visitors of the exhibitions attended. In total, 475 participants completed the questionnaire after having played with *Polymetros*, 690 logs of interaction data were gathered for analysis across the three studies, and 95 instances of participation were transcribed and analysed from the gathered video material.

9.1.1 Key Results

As a key finding, this thesis indicates that in collaborative music making there is a positive association between participants’ perceived level of control and their sense of creative participation and satisfaction with the outcome. Empirical evidence was particularly strengthened by the fact that these associations were found consistently across different socio-cultural contexts and conditions of interaction. This was additionally corroborated by participants’ strong preference for input strategies that would affirm their individual control, by letting them easily recognise their contribution to the co-created music. This was shown to generalise across all three studies through analysis of the interaction data.

In all three studies, the most common social configuration was co-participation, where acquainted audience members participated together by sharing one in-

strument. The act of co-participation was a highly collaborative form of participation that was typically characterised by joint exploration, discussion, explanation and collaborative playing. In general, co-participation appeared to be mainly socially motivated, serving as a strategy to anticipate social discomfort and the reluctance to engage with an as yet unknown system on one's own, in the presence of strangers. For similar reasons, explicit interactions between unacquainted participants were rare, and active engagement amongst players of different instruments mainly occurred between participants who knew each other beforehand.

In contrast, however, it was found that there is tacit mutual awareness amongst unacquainted players, and it was demonstrated that in such multi-person configurations mutual observations led to active exchanges of action between participants.

In all three studies it was found that participants' dwell time was largely determined by social and contextual factors rather than by how they rated their playing experience. Common triggers identified for leaving were an 'obligation to leave' to accommodate other, potentially waiting audience members, and 'leaving by necessity' in order to follow companions who were moving on.

Moreover, it was demonstrated that participants' understanding of and interaction with the system was considerably influenced by their personal predisposition and experience.

9.1.2 Characteristic Differences Between Studies

In all three studies the interactive system established an area of interest that attracted passers-by and spectators to gradually engage with it. These zones of engagement varied across studies. In the more traditional exhibition settings of Study I and II, these areas of interest were closely concentrated around the installation, whereas in the festival setting (Study III) this circle of players and spectators was extended by a larger peripheral audience. This wider social zone around the installation appeared to relate to the generally more loose and fluid

social formations of visitors in the festival environment.

In contrast to Study I (UK) and Study III (Spain), the Chinese audience (Study II) were more hesitant in engaging with the installation and more tentative in exploring it with a trial-and-error approach, a tendency that apparently was related to many visitors' unfamiliarity with interactive exhibits.

More often than in Study I and II, in the festival setting of Study III, initial co-participation was followed by group members taking over instruments on their own. This led to a higher level of active engagement between players as they were acquainted with each other. In general, there was also a higher variability in social configurations amongst players.

While in Study I and II an 'obligation to leave' to accommodate others was a common trigger for leaving, in Study III, participants seemed to be generally less affected by this form of social pressure. This appeared to be related to a difference in attitude between exhibition and festival audiences.

The influence of participants' pre-disposition and experience on their interaction with the system became apparent through the difference in use of features (e.g. Sound Dials, Study II vs. III) and styles of interaction (e.g. performative attitudes in Study III).

9.2 Limitations and Future Work

This section acknowledges limitations of the presented research and provides suggestions for future research.

Participants and Data Collection

While the systematic study of large numbers of unsolicited participants during unaltered, real-world interaction is a particular strength of this research, and has significantly contributed to the ecological validity of the findings, there are some shortcomings to be considered.

Interviews or 'recall' methods could not be used due to a lack of privacy and

space. This prohibited the collection of additional data that might have been helpful to elicit more specific participant responses to their experience. Such methods could have particularly been useful for probing participants' individual understanding of the system (e.g. by letting them explain how they would describe the system and interaction to others). Such insights could, for example, be used to further investigate potential socio-cultural influences on audience interaction. While this could have complemented the systematic evaluation approach of this thesis, it would have required exhibition settings that provide the appropriate preconditions such as private room for interviews and a larger field research team than was available.

A second consideration relates to mechanisms for assessing factors of long-term engagement. During all three studies particular participants could be identified who returned to the installation two or more times (e.g. on consecutive day). However, there were no mechanisms in place to specifically elicit responses from returning visitors (e.g. a particular questionnaire for 'returners'). Such measures could be particularly valuable in order to investigate the 'relater' aspects (Edmonds et al., 2006) of an art system.

Facilitation

In this thesis, it was decided from the outset to offer brief initial guidance to participants due to the deep level of interactivity of the system (see *Understandability and User Experience*, pp. 39-39). Facilitation was restricted to providing initial guidance to individual participants as an entry point, and did not mediate interactions amongst participants. At the end of Study I, an alternative group facilitation strategy was explored. Nevertheless, despite the fact that the strategy appeared promising to encourage more active engagement amongst unacquainted participants, as reported in Bengler and Bryan-Kinns (2013), it was not pursued further in this thesis. The reason for this was to remain focused on investigating how social and interpersonal dynamics evolve *without* such interventions. Future research could explore such strategies and how they

can be effectively designed and employed to promote a deeper level of active engagement between unacquainted participants.

Education

A number of participants suggested using *Polymetros* as a creative musical tool in educational and classroom settings. Within an educational context, studies could investigate aspects of social learning, creative collaboration and teamwork. More generally, related research could investigate how such novel forms of technology-mediated musical creativity can be integrated into, and benefit, traditional music education (cf. Burnard, 2012b). The timeliness of such research is particularly underlined by the recent inclusion of music technology in the UK government’s national plan for music education (DfE and DCMS, 2011), which recommends the use of music technology to extend the range of musical experiences and facilitate wider participation.

Composition and Performance

While this thesis focused on the *process* of impromptu music-making as a casual, open-ended activity for public audiences, tools such as *Polymetros* could also be used to study longer-term musical co-creation, and how working towards a final outcome, such as a composition or performance, influences social dynamics and group creativity. Whilst most research on musical group creativity involved musical experts (e.g. Sawyer, 2003; Nabavian and Bryan-Kinns, 2006), this would allow to study the process of musical co-creation amongst novices. For example, this could be pursued in a longitudinal study based on a series of workshops with the same group of participants, in which they work towards a final musical performance.

Tracking Creative Musical Processes

Analysis tools based on pattern recognition and visualisation of live interaction data, as developed in this thesis, could be used and further expanded to

investigate musical creation processes over time. In contrast to studies which have focused on musical experts (e.g. Healey et al., 2005; Collins, 2007), this would allow researchers to systematically investigate *collaborative* musical creation amongst novices. For example, a study could be designed to let a group of novices freely co-develop a piece of music and then, based on the final result, trace back its process of creation (e.g. by identifying when key elements first appeared, who initiated or adopted them, and how they changed during the process). This could contribute to and extend research on exploring and analysing musical micro-creativity through data analysis and visualisation (Bryan-Kinns, 2014; Bryan-Kinns and Sheridan, 2012).

9.3 Closing Remarks

“...you can think of the piece of music as a representation of a society in which you would be willing to live in and I would prefer to live in a society without a president..”

John Cage (1990, p.178)

This thesis suggests that facilitating a group of people to feel part of a shared creative process is about supporting each individual’s sense of creative control. Therefore, responsibility and challenges lie with the artist or designer to find ways to facilitate, distribute and balance this sense of creative control equally across all participants, to provide them with a level playing field for engaging socially and creatively with each other. It is hoped that this thesis provided some pointers for doing so.

Appendix A


Study I Materials

A.1 Questionnaire

Your age: Your gender: ☐ female ☐ male

Please indicate how the following general statements apply to you.

I am a musical person.



not at all slightly moderately fairly very much

I am experienced using interactive devices (e.g. smart phone, tablet, video gaming).

Please indicate how the following statements apply to your playing experience:

part of a creative process.


I felt in control.

not at all slightly moderately fairly very much

I felt connected to the other players.

not at all slightly moderately fairly very much

It was challenging.



not at all slightly moderately fairly very much

I liked the music we created.

not at all slightly moderately fairly very much

My playing was influenced by the playing of the others.

not at all slightly moderately fairly very much

I would recommend playing Polymetros to my friends.

not at all slightly moderately fairly very much

[FRONTSIDE]

Dear visitor,
we would like you to be part of our research project, if you would like to. You should only agree to take part if you want to, it is entirely up to you.

Information for participants:

Polymetros is part of a research project that aims to transfer the traditionally exclusive experience of musical collaboration to a much broader audience using interactive technology. The objective is to investigate how we can successfully design interactive environments allowing everybody to experience the joy of making music together.

Telling us how you experienced Polymetros allows us to evaluate and refine our current approach and will inform the future direction of our research.

Please ask if there is anything that is not clear or if you would like more information.

Consent statement:

I agree that the research project has been explained to me to my satisfaction and I agree to take part in this study.

I consent to the processing of my personal information for the purposes of this research study.

understand that such information will be treated strictly confidential and handled in accordance with the provisions of the Data Protection Act 1998.

Signed: _____ Date: _____

A.2 Field Notes

Categorised field notes V&A

Date: 22nd and 23rd September 2012

[] inserted during transcription for clarification

1 Player actions

Saturday 22.09.2012

- An older couple (50-60) participates at instrument 2 together: At first, the husband figures out how to play on his own, then he creates a phrase and uses it to explain to his wife how the instrument works.
- At instrument 2, a young boy (8-10) participates together with his mother: He is playing the instrument while his mother is commenting on his actions. At one point they discuss how the same musical output can be realised in different ways.
- Two men (25-30) play together on instrument 2: They are co-edit their phrase together while talking. They comment on their actions and appear to negotiate what they are going to try next. While playing, they are nodding their heads to the beat and laugh occasionally.
- A young boy (8-10) figures out how to dynamically play up and down the instrument's musical scale: He creates an upwards diagonal using all eight steps, then sets the loop length to one and dynamically moves the selection around via the loop shift buttons.
- A young man (20-25) successively switches between instrument 2 and 1: He uses the mute function rhythmically in relation to the other players' phrases (requires awareness and close listening to the other players). He also prearranges material on the currently deactivated section of the note grid which he then launches gradually.
- At instrument 2, a couple (25-30) figures out the instrument together and continues co-editing by input and delete notes in turn.
- At instrument 2, a player organises his input in a way that appears to be a 'systematic' strategy to clearly spot his input in the overall musical output: He starts by creating a closed straight line of notes (no rests). Successively, he changes one note at a time and then lets the new variation play for several times before making another, similar edit.
- A couple (30-40) participates at instrument 2 together: The husband explains to his wife how the instrument works. They then play together for a while before he takes over the instrument on his own. He comments towards the research assistant: "That's lovely. That's great fun". His wife is waiting next to him.
- A young man (20-25) who played on instrument 2 earlier, approaches and explains the instrument to a mother and her child.

Sunday 23.09.2012

- A young girl (7-10) plays a long time on instrument 1 (>15min). She shows a comprehensive understanding of the instrument by using and combining most of the available functions. After finishing playing, she 'sticks around' and subsequently explains the instrument to newly arrived audience members.
- A group of children arrives and spreads across all three instruments. The facilitator (research assistant) invites them to wipe all the notes from their instruments at first, and then to join in one after another. The group understands very quickly how the instruments work and is aware from the outset 'who is playing what'. (round-based approach seems a good strategy for initial facilitation, but is only practicable at less busy times).
- At instrument 3, a boy (8-10) 'discovers' how to play the instrument using a single note. He sets the loop length to one and dynamically resets a single note on the active, single column.
- A woman (30-35) who plays on instrument 2 'discovers' the pitch shift function and changes the pitch range of the pattern dynamically. While doing so, she comments her action across the table addressing her companion playing at another instrument: "Now I gonna go higher. (...) And now I gonna go lower".
- Similar as yesterday [Saturday], a man (20-25) rhythmically mutes his instrument in coordination with the patterns of the other players (implies explicit awareness).

2 General remarks

Saturday 22.09.2012

- A very common input strategy is the creation of 'geometric' figures that use all available notes on the grid (no rests). Very common: Upwards diagonal, and combined diagonal figures (e.g. up-down). It appears to be a good way to understand how the instrument works and what it is playing.
- Many visitors touch and turn the instruments' illuminated sphere [Sound dial function not yet implemented] which appears to have a strong affordance to touch.
- Bystanders gather around the installation (often in groups) and closely observe the active players. By watching, they apparently aim to figure out how the instruments work.
- It appears that the main reason for players 'loosing track' of their contribution is that their instrument is set to either a very low or very high pitch range and interferes with another instrument set to the same range.
- In general, people are often observed to participate together on one instrument, explore its functionality together and explain how it works to each other.
- It seems not obvious to all people that the overall musical output is created entirely from the current three phrases playing on the pads. As an example, one participant remarks that he wonders "what the computer plays on top of it". It appears to be most evident

that the output is if all players start together with an empty grid.

- The understanding that all of the heard music is actually created by the active players is promoted most effectively if players start from an empty note grid and, in the best case, join in one after another. However, this is rarely happening by chance in the busy, public environment and would need systematic facilitation.
- In the afternoon active players are often surrounded by 5-10 people watching at the same time.

Sunday 23.09.2012

- Despite the fact that many people are able to figure out how to play on their own, it appears that facilitation also promotes a higher level of awareness among different players. E.g. if facilitation is provided to a newly arrived player, other players at the table - often entirely focused on their instruments - look up and follow the facilitation across the table (hoping to learn something new?) which raises their awareness for the other players' actions and their contributions.
- As yesterday [Saturday], people often participate by sharing one instrument and first explore and then play it together.
- In the afternoon, parents were often observed to explore the systems together with their children on a shared instrument. Several child/parent pairs spent a long time playing on one instrument together.
- It appears promising to adapt the facilitation strategy according to more detailed observations (video analysis?) of players who successfully figure out how to play on their own (e.g. using commonly observed 'geometric' figures)
- As yesterday [Saturday], the most commonly observed input strategy are 'geometric' figures (e.g. horizontal or diagonal lines) consisting of consecutive notes (no rests).
- It appears that people who particularly enjoyed their playing sometimes feel the 'urge' to help and explain the instrument to others (including strangers).

3 Verbal responses

Saturday 22.09.2012

- Whilst playing at instrument 3, a woman (35-40) comments towards the research assistant: "It's really addictive and it's good for kids. Our son would love this".
- After finishing playing a participant comments: "It's really fun, it's like a family game".
- At instrument 2, a girl (15-18) explains how to play the instrument to her friend. When her companion understands the functional principle, she states: "I want to have a go now."
- After receiving a short initial guidance by one of the research assistants an older man comments: "Wow, its great!".
- At instrument 2 three teenage girls pressing note buttons quite randomly and have apparently not yet understood the loop-based concept. One of them comments: "I wanna have one of these".
- A young man (20-25) comments towards one of the research assistants: "It's hypnotic. It's easy to get lost in the sounds."
- A player discovers the pitch shift function and while chancing the pitch of his phrase back and forth several times comments: "Oh that's me!"
- A player switches his instrument into a high pitch range. Another player at different instrument ask across the table: "Who is this?"
- A group of three approaches the researcher and comments: "I played here earlier. It's so addictive. We were here for hours."
- Whilst playing on instrument 1, a woman (25-30) comments: "It's amazing. I could do this for hours".

Sunday 23.09.2012

- After finishing playing, a man (35-40) addresses the researcher and suggest to use Polymetros for team-building seminars.
- A man (25-30) comments towards the research assistant whilst playing on instrument 2: "I love the loop shift function".
- After finishing playing at instrument 1, a girl (12-15) comments towards the facilitator (research assistant): "It's amazing. I so want some of these at home".
- Whilst playing on instrument 1 with his son (7-9), a father (35-40) comments towards one of the research assistants: "It took us a little while but now we have it. That's really great!"
- A young girl playing at instruments 2 is rhythmically moving to the beat. She comments towards the facilitator: "It's so brilliant. It really gets you".
- An elderly woman (~50) who played a long time (>15min) at instrument 3 comments toward the researcher: "This is so cool. I had so much fun. I have to come back later".
- While playing on instrument 2 for already quite some time (>10min), a woman (30-35) comments towards the research assistant: "I am so into it. I would play that with my friends at home. It's so much better than monopoly".

A.3 Video Annotations

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Date: 22.09.2012
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Scene 1 (1:36)

Participant(s) description: Mother (35-40) and daughter (10-12) (P1, P2).

P1 and P2 approach instrument 1 (previous pattern still running). P2 presses some note buttons but has apparently not yet understood the loop based concept (rhythmical input). They are approached by the facilitator (F) who explains the instrument while pointing along the pattern with his finger. After F leaves, P2 deletes all notes from the grid and starts setting notes (still quite 'randomly'). After a short while, P1 appears to loose interest and moves on. P2 remains for a moment, than follows P1.

Scene 2 (3:00)

Participant(s) description: Couple (45-55), (P3[m], P4[w]).

P3 and P4 approach the instrument whilst previous pattern is still running. P3 changes several notes and appears to quickly understands how it works. P3 follows the pattern with his finger in order to visualise to his wife what their phrase is. P3 creates variations of the phrase. P3 then reorganises all notes into a straight line and uses it as basis for new pattern: P3 places single notes (only one at the time) 'out of line'. P3 then creates more 'complex' patterns pattern. While playing, P3 chats to P4 (not editing) and they appear to discuss about the instrument (P4 points towards the note grid).

Scene 3 (8:08)

Participant(s) description: Young boy (6-8) (P5).

P5 approaches the instrument while the facilitator is showing the use of the mute button (phrase of the prior person is still running). P5 takes over the instrument and dynamically plays with mute function. P5 reorganises all notes into a straight line and then reduces the section to one. From aside another visitor (not acquainted with P5) sets a note on the grid and P5 immediately leaves the instrument.

Scene 4 (9:40)

Participant(s) description: Men (25-30) (P6).

P6 arrives at the instrument when no notes are set on the grid. P5 creates a 'closed', straight line of notes and then deletes single notes out of it and brings them back. (Interface partly occluded by onlooker). P5 deletes all notes from the grid and then builds up a new pattern in a gradual manner by adding a single note at each playback cycle. Then P5 resets all notes and starts building up a new pattern in a similar way, which he continues doing (gradual built up, then reset). P5 receives a phone call and leaves the installation.

Scene 5 (14:22)

Participant(s) description: Young boy (10-12) (P7), accompanied by his little brother and mother.

P7 approaches the instrument (phrase of the prior person is still running) and starts pressing several note buttons rather 'randomly'. His little brother reaches up to the instrument as well and presses buttons in quick succession. After a short while, the mother signals them that she wants to move on and takes his little brother by the hand. P7 appears to ask if he can stay; but she moves on and P7 stays. His mother returns a little later and urges him to leave ("Come on".) and he leaves the installation.

Scene 6 (16:20)

Participant(s) description: Couple (25-30), (P8[w], P9[m]).

Before P8 and P9 take over the instrument (previous pattern still running) they stand at some distance from the table (~1.5m) and observe the active players. P8 sets some notes, then P9 deletes all notes from the grid. P8 creates a new pattern. When P9 becomes aware that another instrument became available he changes to the other instrument (interface outside of camera's viewing angle), P8 remains at the initial instrument. While continuing playing, P8 focuses on P9's instrument for several times (it appears that P8 'picks up' the tempo change function from him) and they occasionally chat across the table. Before P8 leaves, she wipes all the notes from the grid.

Scene 7 (17:54)

Participant(s) description: Very young child (4-6) (P10), accompanied by mother.

P10, just about able to reach for the instruments, presses note buttons 'randomly' with both hands, and seems highly attracted by the instruments. His mother comments towards the facilitator: "I think its all about the colour. (...) I think this is the highlight of the day for now". After a while, she asks P10 and another child who is acquainted to her to leave: "Should we go now?" Child: "No." Mother: "We need to give other people chances, ben, yeah. Come on". All three leave the installation.

Scene 8 (20:45)

Participant(s) description: Girl (14-16) (P11).

P11 approaches the installation whilst all instruments are taken. P11 closely observes the active players at instrument 2. When instrument 1 becomes available, P11 takes over the instrument (phrase of the prior person is still running). After changing several notes, P11 rearranges all notes into a straight line, then into an upwards diagonal. P11 then creates variations of 'closed' (no rests) musical figures (diagonals, up/down combinations). P11 is joined by her father: She demonstrates how the instruments works by pointing along the pattern, then creates a straight line of notes, then an upwards diagonal. When her father steps aside, P11 remains playing for several minutes creating closed musical figures and then gradually more sparse patterns resetting the grid several times before starting a new pattern.

Scene 9 (30:50)

Participant(s) description: Four teenage girls (15-17) (P12, P13, P14, P15).

P12 and P13 take over instrument 1 (previous pattern still running) while P14 and P15 remain standing between instrument 1 and 2 and observe the active players. P12 and P13 simultaneously input notes in a rather 'random' manner. P12 addresses the facilitator (F): "What is this?". F explains the loop based concept on instrument 3; P12, P13, P14 watch. P13: "I get it". P13 creates closed figure (upwards

diagonal, downwards diagonal, straight line) and follows the patterns with her finger (P12 exclaims: "ah".) P12 creates a straight line pattern as well. In the meantime, P14 and P15 have joined a girl on instrument 2 they apparently know. P12 and P13 continue co-editing (interface occluded by on-looker). Before they leave, they delete all notes from the grid.

Scene 10 (37:12)

Participant(s) description: Young man (20-25) (P16), later joined by a friend (man, same age) (P17).

When P16 approaches the instrument, the phrase of the prior player is still running. P16 presses note buttons rhythmically and tries several function buttons, but does not yet understand the loop based interface concept. P16 is joined by P17 who explains the instrument to him: At first, P17 resets the grid and creates a closed musical figure (downwards diagonal combined with straight line). Then he rhythmically points at every played note following the pattern for several playback cycles. After signalling his understanding (exclamation: "Ah!"), P16 points along with the pattern before turning to P17 who acknowledges his understanding with a nod.

Scene 11 (44:30)

Participant(s) description: Man (25-30) (P18).

When P18 approaches the instrument, the phrase of the prior person is still running. After pressing several note buttons, P18 creates a pattern and varies it 'systematically' by changing a single note per playback cycle. P18 addresses the player on the instrument next to him: "Are you playing higher notes there?" (..) "This is really good." P18 creates more sparse patterns and changes the pitch range several times. P18 addresses the researcher and comments while pointing at Polymetros: "It's a Brian Eno machine (..) you can easily get lost in this rhythms, can't you?". P18 engages in a conversation with the researcher asking him about the technical details of the installation (e.g. what generates the sounds, how the instrument stay in sync) and the project in general.

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Scene 12 (19:50)

Participant(s) description: Woman (25-30) (P19), joined by her boyfriend later (P20).

When P19 approaches the instrument the note grid is wiped. P19 sets several notes and repeatedly reorganises them into different patterns (seems like that she has not full understood the loop based concept yet). P19 is joined by P20 who observes the instrument while P20 is asking the facilitator: "What is this designed for?". In the meantime, P20 has deleted all notes from the grid. P20 sets two notes and lets the pattern repeat for several times, then adds successively more notes to create a downwards diagonal. P19 and P20 start to try out different functions together (e.g. pitch shift, loop shift). P20 sets the loop length to four via the buttons in the top row and follows the active pattern with her finger. They continue coediting for several minutes, varying the pattern in turns and apply different functions (P19 makes occasional dance moves). When P19 becomes aware of a woman standing close to her at the table watching, she makes an inviting hand gesture and P19 and P20 leave the installation.

Scene 13 (36:40)

Participant(s) description: Man (24-26) (P21).

Having played on another instrument before for around 5 minutes, P21 switches over to instrument 1 after it became available. (It appears that the girl at the third instrument is his girlfriend and they occasionally chat across the table) At first, he resets all notes on the grid and creates a 'sparse' rhythmical pattern. P21 stretches over to instrument 2 (the one he played on before) and starts playing on two instruments by alternately changing the patterns in turns. It appears P21 tries to coordinate both patterns to his liking, then focuses back on one instrument. P20 holds down the mute button and 'brings in' parts of the pattern rhythmically. P20 sets the loop length to four and dynamically edits a four note pattern.

Scene 14 (48:00)

Participant(s) description: Woman (30-35) (P22).

P22 arrives at the installation whilst all instruments are taken. She stands at some distance to the table (~1.5m) and closely observes the facilitator explaining the instrument to a young child. When the instrument next to her becomes available P22 takes it over. P22 sets the loop length to two and creates a two note pattern. Then P22 gradually extends the loop length and adds additional notes. She appears to read the labels of the function buttons, changes the pitch and then takes a picture of the instrument. P22 is approached by one of the facilitators (F) asking if she 'has worked it out'. P22 comments: 'I was listening to the instructions [the facilitator gave to other player], that helped a lot.' and 'explains' the note grid and several function (e.g. loop shift) to F. F leaves, P22 continues playing.

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Scene 15 (05:30)

Participant(s) description: Young man (20-25) (P23).

P23 arrives at the installation whilst all instruments are taken. He stands at some distance to the table (~2m) and observes the active players. When instrument 1 becomes available P23 takes it over. At first, P23 resets all the notes, then creates a series of closed figures (straight line, downwards diagonal). P23 creates an alternating pattern based on two different pitches and dynamically changes the loop length. P23 uses different function buttons (tempo change, pitch shift) and tries to turn and push the illuminated sphere [sound dial function not yet implemented]. P23 is joined by a man who closely observes his playing (it is not apparent if they know each other, they do not talk). After a short while, P23 takes a step back while making an inviting gesture towards the onlooker who takes over the instrument.

Scene 16 (07:50)

Participant(s) description: Young man (20-25) (P24).

P24 arrives at the installation and closely observes the active player at instrument 1 (Scene 15) who, after a while, hands over the instrument to P24 (previous pattern still running). P24 starts editing the pattern by consistently rearranging its note sequence (it is not obvious however, if he entirely understands the loop based playback). Then, P24 focuses on the function buttons on the left, switches the pitch range back and forth for several times, then the playback tempo. (player obscured by research assistant blocking the camera). P24 continues editing (still not sure if he understood how the note grid works), then leaves.

Scene 17 (12:20)

Participant(s) description: Woman(35-40) (P25), accompanied by a man and another woman (30-35) (P26, P27).

P25 arrives at the installation and takes over instrument 1 (previous pattern still running). P26 stands next to her and P27 at some distance between P25's and the next instrument. P26 appears trying to explain the instrument to P25. When he aims to demonstrate something on the note grid P25 'brushes' his hand aside. P25 discusses with P26 (who is apparently not entirely sure how it works either). The facilitator (F) gives a hint and points out the loop based playback of the pattern. P25 nods and comments: "Ah, cool", when she understands the concept. P26 and P27 nod as well. P25 continues playing, editing notes, loop length and applying different functions while occasionally chatting to P26 and P27. After P26 and P27 have left the installation, P25 approaches the research assistant to ask for details about the installation before leaving.

Scene 18 (23:40)

Participant(s) description: Man (30-35) (P28).

P28 arrives at the installation whilst all instruments are in use and positions himself at some distance to the table (~1.5m) observing the active players. After waiting for around one minute, instrument 1 becomes available (previous pattern still running). P28 starts editing the pattern and lets every variation play for several playback cycles. After a while, P28 reorganises the notes more and more into closed musical figures (upwards/downwards diagonals). P28 then deletes all the notes and creates several alternating pattern based on two different notes, then leaves.

Scene 19 (30:20)

Participant(s) description: Couple (30-35), (P29[m], P30[w]), joined later by two woman (same age) (P31, P32).

When P29 and P30 arrive at the installation they first stop at some distance (~2m) to watch before taking over instrument 1 (note grid wiped). P30 sets and immediately resets single notes (no effect). P29 addresses the facilitator (F) who is standing in close proximity. F sets the loop length to four, creates a simple four note pattern and points along the notes while explaining the loop based playback. P30: "Ah." P29 starts editing creating mostly closed musical figures (downwards diagonal, straight line, upwards/downwards diagonals). P29 then takes out his mobile phone and takes a close-up video of the instrument. After finishing the video P29 leaves the installation and P30 takes over the instrument. She mainly creates closed musical figures and occasionally changes loop length and pitch range. P30 is joined by P31 and explains the instrument to her by creating a closed downwards diagonal and pointing along the played notes to indicate the loop based playback. Both are joined by P32 and P30 repeats this explanation in a similar manner. All three then edit the pattern in turn before P30 and P32 leave the installation, and P31 is taking over the instrument.

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Scene 20 (06:30)

Participant(s) description: Couple (25-30), (P33[m], P34[w]).

After observing the installation from some distance (all instruments are in use), P33 and P34 take over instrument 1 once the prior player leaves (previous pattern still running). At first, they change several notes of the pattern but appear to not understand the loop based concept. The facilitator (F) reaches across the table and points along the pattern with his finger (It appears that this 'hint' did not yet lead to an understanding). After creating several closed figures, P33 seems to finally understand the interface and rhythmically points along the played notes while chatting to P34. Then P34 creates several patterns also pointing along with her finger. P34 then points to the other instruments. Before switching to another instrument, P34 seems to memorise the last phrase they have created. After a short moment, P33 follows her and they both continuing playing at instrument 2 for several minutes before they leave (interface outside of camera's viewing angle).

Scene 21 (10:00)

Participant(s) description: Couple (25-30), (P35[m], P36[w]).

P35 and P36 approach instrument 1 (grid wiped). P35 stands in front of the instrument while P36 positions herself somewhat aside in an 'observational' position. P35 starts editing (appears to initially understand the loop based concept) and asks the facilitator (F): "Where is the tempo? (...) Ah, I saw it". While P35 continues editing, P36 moves over to the next instrument, sets several notes (bright pitch) and exclaims: "That's me!" (laughs). P35 looks across the table. P36 then asks F: "Can I press any button, there is no right or wrong?" F reaches across the table and points out the loop based playback. After playing for a while P36 comments: "That's powerful. It does not make sense till you go on it". P35 and P36 continuing playing on their instruments while occasionally chatting across the table (camera temporarily obscured by research assistant). When a very high pitched phrase starts, P36 looks up from her instruments and asks across the table: "Who is that?". Turning towards the (apparently unknown) player next to her P36 ask: "Ah, it you. How did you do that?" The player demonstrates the pitch shift function. When a young child on the arm of its father who is standing next to P36 points at the instrument while babbling, P36 makes an inviting gesture towards the man and leaves the instrument. P36 returns to P35 who continues playing while P36 takes pictures and engages in a conversation with one of the research assistants.

Scene 22 (25:15)

Participant(s) description: Couple (25-30), (P37[m], P38[w]).

P37 and P38 arrive at the installation whilst all instruments are taken. They position themselves close to instrument 1 and observe the active players. When the player steps back from the instrument (it appears he might have been obliged by P27 and P38's apparent waiting next to him, he remains close to the installation watching) they take over the instrument (previous pattern still running). In turn, they delete

and set several notes and press different function buttons. It appears P38 understands first 'how it works' and explains to P37 while pointing along the pattern with her finger. After a while, P37 comments: "Oh, yea. (...) Got it." They continue coediting the pattern in turn. They create a straight line of notes and gradually alter it into another closed figure (up/down diagonals). Letting the pattern unchanged, P37 then applies various functions (e.g. loop length edits, pitch shift). Then both leave.

Scene 23 (30:45)

Participant(s) description: Couple (20-25), (P39[w], P40[m]).

When arriving at instrument 1 (grid wiped) P39 positions herself in front of the instrument, P40 somewhat aside in an 'observational' position. P39 asks the facilitator (F): "Is there any kind of rule? Just press buttons?" F tries to indicate the loop based manner but P39 does not seem to be particularly attentive and is inputting notes with both hands. After a while, she turn to F again: "I don't understand it". F points along the 'light bar' and explains that it is triggering the notes. P39 (understanding the concept): "Ah". P39 creates a straight line of notes and successively transposes it across the grid. P39 and P40 then start coediting the pattern together: They create and edit patterns in turn, apply different functions (e.g. loop shift, pitch shift, loop length edits) and continue playing for further six minutes. Before leaving P39 comments towards F: "It's fantastic".

File: M2U00100

Date: 22.09.2012

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Scene 24 (08:20)

Participant(s) description: Young woman (18-22) (P41), joined by a friend later (female, same age) (P42).

P41 arrives at the installation whilst all instruments are taken. She positions herself between instrument 1 and 2 and observes the active players for around 3min. When instrument 1 becomes available P41 starts editing by reaching over from her position between the instruments (rather than moving in front of it). Shortly after, she is joined by P42 and P41 starts explaining the instrument to her: P41 wipes all the notes from the grid and gradually builds up a pattern (adds a new note at each playback cycle) and follows it with her finger. P41 then points to the other instruments (It appears she points out what sounds come from the other instruments). Finally, P41 demonstrates how to change the loop length. P42 then takes over the instrument and P41 moves on. P42 continues playing for several minutes by creating (mostly) closed musical patterns and dynamically changing the loop length.

Scene 25 (14:00)

Participant(s) description: Boy (12-14) (P43).

P43 arrives at the installation whilst all instruments are taken. (He has played shortly earlier but left to 'make way' for a waiting couple, see Scene 22). P43 remains at a little distance from the table (~1m) and observes the active players. When instrument 1 becomes available he takes over the instrument (grid wiped). P43 gradually builds up a 'sparse' pattern letting each variation play for at least once before adding a new note. P43 then wipes all the notes and repeats this step-wise, gradual build up. He then adapts the created pattern by chancing single notes in a - as it looks - well-considered manner. When the facilitator points at 'his' instrument during a conversation with the research assistant P43 quickly steps back and leaves the installation.

Scene 26 (15:15)

Participant(s) description: Boy (12-14) (P44).

P44 arrives at the installation whilst all instruments are taken. Together with his friend P44 stands close to the table and observes the active players (for ~2min). When instrument 1 becomes available, P44 moves around the table and takes over the instrument (previous pattern still running). At first, P44 reorganises all notes into a straight line. Letting the line pattern play he 'systematically' tries out the function buttons on the left, then deletes all notes from the grid and shortly speaks to his friend who is still watching from the other side of the table. P44 then sets two consecutive notes and moves this short pattern dynamically up and down on the grid to change its pitch after each repeat. P44 continues with this dynamic input style (while adding/deleting additional notes with the other hand) for around 2.5 minutes entirely focused on his instrument. P44 then looks up from the instrument (his friend has left the installation in the meantime) and briskly leaves the installation.

File: M2U00101

Date: 22.09.2012

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Scene 27 (4:45)

Participant(s) description: Two woman (25-30) (P45, P46).

P45 and P46 arrive at the installation whilst all instruments are in use. They stand at some distance from the table (~1.5m) and observe the active players before taking over instrument 1 once it becomes available (previous pattern still running). At first, P46 changes the loop length via the button row at the top, then both closely observe the running pattern. While discussing P45 and P46 are pointing along with the pattern in turn: P46 'augments' the progression of the 'light bar' with a chopping gesture. P45 follows the playback with the finger while commenting ("It going there, there, .. and there."). While constantly discussing, they try out different functions (tempo change, pitch shift) before the start co-editing the pattern mostly creating closed figures (straight line, diagonals). Several times during their interaction they look at each other and burst into laughter.

Scene 28 (10:30)

Participant(s) description: Young man(20-25) (P47).

P47 arrives at the installation whilst all instruments are taken. He positions himself between instrument 1 and 2 and observes the active players. Once instrument 1 becomes available, P47 takes over the instrument (note grid wiped). P47 starts from a single note and gradually adds notes letting each variation play at least once (3x), and then extends the phrase into a closed pattern (two alternating pitches). P47 then reorganises all notes into a straight line and transposes it before creating more complex (but still mainly closed) musical patterns. He also creates variations by changing the loop length. After continuing playing for another minute, P47 deletes all the notes from the grid, looks towards an onlooker next to him who is closely observing him, and takes a step aside. The instrument is immediately taken

over by the onlooker.

Scene 29 (13:40)

Participant(s) description: Man (30-35) (P48), later joined by a woman (25-30) (P49).

P49 arrives at the installation whilst all instruments are in use. He positions himself next to instrument 1 and observes the active player (Scene 28). When the player takes a step aside, P49 'moves up' and takes over the instrument (grid wiped). P49 starts editing by creating a straight line and tries out several functions (loop length edit, tempo). P49 arrives at the installation and stands next to P48. P48 creates an ascending pattern and varies it by dynamically changing the loop length. P48 then starts to explain the instrument to P49: He deletes all notes from the grid and points out the playback direction with his hand. He points at the two other instruments (it appears he explains how they all play together). P48 then creates a closed straight line of notes and follows its playback with his finger and then repeats the explanation with another pattern. P49 starts editing. When P48 approaches the facilitator (F) to ask for technical details, P49 takes over the instrument on her own. P49 successively tries out the different functions (pitch short, tempo, mute, loop shift) while varying the loop length. Then P49 leaves the installation on her own (P48 is still talking with F).

Scene 30 (45:00)

Participant(s) description: Young man (20-25) (P50).

P50 arrives at the installation whilst all instruments are taken. Standing close to the table, he observes the active players. When instrument 1 becomes available, he moves around the table and takes over the instrument (previous pattern still running). P50 extends the loop length and creates a closed musical figure. He 'discovers' the loop shift function and uses it repeatedly to move the active section back and forth across the pattern. Over time, he reorganises his pattern into more and more 'open' figures which he varies in a stepwise manner (one note edit per playback cycle). Repeatedly, P50 resets all notes and starts a new pattern from scratch while more and more incorporating functions such as pitch shifts and tempo changes into his playing. When a woman and her young daughter arrive at the table next to him, P50 turns towards them, makes an offering gesture with both hands and slightly pushes the instrument towards the girl. P50 then steps aside and leaves the installation.

Appendix B

Study II Materials

B.1 Questionnaire [Chinese, English]

年龄

性别 ☐ 女性 ☐ 男性

请回答以下适用于您的陈述

音乐对我来说很重要

☐ 强烈不认同 ☐ 不认同 ☐ 没感觉 ☐ 认同 ☐ 强烈认同

我有过正规的音乐培训 (例如: 演奏乐器)

☐ 强烈不认同 ☐ 不认同 ☐ 没感觉 ☐ 认同 ☐ 强烈认同

我经常使用交互式的设备 (例如: 智能手机, 平板电脑, 视频游戏)

☐ 强烈不认同 ☐ 不认同 ☐ 没感觉 ☐ 认同 ☐ 强烈认同

对于在体验本系统的过程中, 请您回答以下问题

我感觉自己处于一种创造性的过程中

☐ 强烈不认同 ☐ 不认同 ☐ 没感觉 ☐ 认同 ☐ 强烈认同

我能够很好的控制

☐ 强烈不认同 ☐ 不认同 ☐ 没感觉 ☐ 认同 ☐ 强烈认同

我觉得我和其他玩家是相互联系起来的

☐ 强烈不认同 ☐ 不认同 ☐ 没感觉 ☐ 认同 ☐ 强烈认同

这款游戏很具有挑战性

☐ 强烈不认同 ☐ 不认同 ☐ 没感觉 ☐ 认同 ☐ 强烈认同

我喜欢我创作的音乐

☐ 强烈不认同 ☐ 不认同 ☐ 没感觉 ☐ 认同 ☐ 强烈认同

在我玩的过程中, 同时也受到了其他玩家的影响

☐ 强烈不认同 ☐ 不认同 ☐ 没感觉 ☐ 认同 ☐ 强烈认同

我会把这款游戏推荐给我的朋友

☐ 强烈不认同 ☐ 不认同 ☐ 没感觉 ☐ 认同 ☐ 强烈认同

[FRONTSIDE]

[BACKSIDE]

尊敬的来宾,

如果您愿意的话, 我们很荣幸的邀请您成为我们研究课题的一部分。只有当您同意的情况下, 才可以参与本项课题研究。

参与者信息

这项系统(Polymetros)是一项为研究如何用交互式系统把传统的协作性音乐方式传递给更广泛的观众的观众的研究课题一部分。其目标在于研究我们如果能够成功地设计交互式环境使得每个体验者都可以感受到创作音乐的魅力。

您的反馈将能使我们更好的改进和评估我们目前的方法, 从而引导我们未来的研究方向。

如果您需要更多的信息或者对本系统不清楚, 请随时向我们提问。

同意陈述

在解释的情况下, 我同意并且乐意参加本项课题研究。

我同意把我的个人反馈作为本项课题研究的一部分。

我了解这些信息将会严格保密, 并且严格服从数据保护法规定。

签字 _____ 日期 _____

Music is very important for me.

☐ not at all ☐ slightly ☐ moderately ☐ fairly ☐ very much

I had formal musical training (e.g. I play an instrument).

☐ not at all ☐ slightly ☐ moderately ☐ fairly ☐ very much

I am experienced using interactive devices (e.g. smart phone, tablet, video gaming).

☐ not at all ☐ slightly ☐ moderately ☐ fairly ☐ very much

Please indicate how the following statements apply to your playing experience.

I felt part of a creative process.

☐ not at all ☐ slightly ☐ moderately ☐ fairly ☐ very much

I felt in control.

☐ not at all ☐ slightly ☐ moderately ☐ fairly ☐ very much

I felt connected to the other players.

☐ not at all ☐ slightly ☐ moderately ☐ fairly ☐ very much

It was challenging.

☐ not at all ☐ slightly ☐ moderately ☐ fairly ☐ very much

I liked the music we created.

☐ not at all ☐ slightly ☐ moderately ☐ fairly ☐ very much

My playing was influenced by the playing of the others.

☐ not at all ☐ slightly ☐ moderately ☐ fairly ☐ very much

I would recommend playing Polymetros to my friends.

☐ not at all ☐ slightly ☐ moderately ☐ fairly ☐ very much

[FRONTSIDE]

Dear visitor,
we would like you to be part of our research project, if you would like to. You should only agree to take part if you want to, it is entirely up to you.

Information for participants:

Polymetros is part of a research project that aims to transfer the traditionally exclusive experience of musical collaboration to a much broader audience using interactive technology. The objective is to investigate how we can successfully design interactive environments allowing everybody to experience the joy of making music together.

Telling us how you experienced Polymetros allows us to evaluate and refine our current approach and will inform the future direction of our research.

Please ask if there is anything that is not clear or if you would like more information.

Consent statement:

I agree that the research project has been explained to me to my satisfaction and I agree to take part in this study.

I consent to the processing of my personal information for the purposes of this research study.

I understand that such information will be treated strictly confidential and handled in accordance with the provisions of the Data Protection Act 1998.

Signed: _____ Date: _____

Queen Mary Research Ethics reference number: 1182

[BACKSIDE]

B.2 Video Annotations

File: M2U00038_Part1
Date: 12.05.2013
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Instance: 1 (0:22-2:16)
Instrument 3
Participant(s) description: Man (P1), joined by a woman later (P2).

Approaching: Pattern of previous player still running (3 beats long). P1 deletes all notes.

Playing Techniques and Interaction :

(0:22) P1 sets notes, extends the grid successively to eight steps and creates open figures using all eight steps.
(1:15) P1 lets the same pattern running while talking to P2 who joined him.
(1:37) P2 takes a picture and starts editing P1's pattern. P2 is creating a closed linear figure (straight), then repeats to create a closed linear figure (straight) on a different pitch.

Leaving: While P2 is still editing, P1 turns around touching her arm as indication to leave. P1 leaves and P2 follows.

Facilitation: No
Co-participation: Yes (both editing)

Instance: 2 (2:16-3:30)
Instrument 3
Participant(s) description: Man (25-30) (P3).

Approaching: The pattern of previous player still running (8 beats long). P3 bends down to listen closely to the instrument.

Playing techniques and interaction:

(2:16) At first, P3 deletes all notes. Then, P3 is creating a closed linear figure (straight), transform it into a closed linear figure (upwards diagonal), then a downwards diagonal and alternates both patterns several times.
(3:05) P3 shortly touches the dial turning it just a small amount left and right (probably too less affect the sound).
(3:18) P3 enters a random pattern with both hands, then leaves.

Leaving: -
Facilitation: No
Co-participation: No

Instance: 3 (4:16-5:56)
Instrument 2
Participant(s) description: Young couple (20-25), woman (P4), man (P5).

Approaching: All instruments have been wiped before, P4 and P5 approach instrument 2 (loop length 7).

Playing techniques and interaction:

(4:16) Facilitator explains the interface. After the explanation, P4 starts editing, while P5 steps toward the video display and watches the showreel.
(5:18) P4 indicates P5 to come back to the instruments and explains to him 'how it works' by using a closed linear figure (upwards), and demonstrates how to vary the loop length.

Leaving: A child approaches the instrument and watches them closely. P5 takes a step back from the instrument and both leave soon after.

Facilitation: Yes
Co-participation: Yes (primarily woman editing)

Instance: 4 (10:06-12:50)
Instrument 1
Participant(s) description: Two young women (P6, P7).

Approaching: The pattern of previous player still running (loop length 8).

Playing techniques and interaction:

(10:06) P6 sets several notes, but it appears that both did not understand the loop-based interface concept, as she inputs the notes 'rhythmically'.
(10:20) The facilitator (F) approaches and demonstrates the basic concept by using an upward closed musical figure.
(11:05) P6 and P7 reset the grid after F left and start co-edit several musical phrases and commenting the changes to each other.
(11:50) P7 wipes the grid and creates an upward diagonal using all eight steps. Both try to sing along "do-re-mi-fa-so -..".
(12:05) They create a downward diagonal, followed by several combined patterns, resetting the grid several times before creating a new pattern.

Leaving: The curator asks to stop Polymetros for the time of a performance taking place, and all participants are forced to stop playing.

Facilitation: Yes
Co-participation: Yes (joint co-editing)

File: M2U00038_Part2
Date: 12.05.2013
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Instance: 5 (5:15- 9:27)
Instrument 3
Participant(s) description: Man (P8), alone at first joined by woman later (prob. girlfriend) (P9).

Approaching: The note grid is wiped. P8 is observing the installation from some distance.

Playing techniques and interaction:

(5:15) The facilitator (F) encourages P8 to step closer and demonstrates the basic concept by setting a single note on grid.
(5:26) P8 sets several notes and is joined by P9. F explains how to change loop length.

(6:08) They try out the explained features together: P8 is editing the notes, P9 is varying the loop length at the same time.
 (6:48) P8 is trying out other function buttons (pitch shift, loop shift).
 (6:58) Then P8 set loop length to eight and creates a closed linear figure (straight), then several closed alternating patterns, closed linear figure (downwards), closed linear figure (up-down).
 (7:38) P9 touches the dial (right after facilitator showed dial to player on instrument 1), P9 turns it all the way down and holds it for a moment, then they continue editing (not sure if they were aware of the dials effect on the sound)
 (8:10) P8 and P9 dynamically co-edit loop length and pattern.
 (8:25) P8 lifts the instrument and turns it around for inspection, then P8 is explaining to P9 instrument's functions successively.
 (9:27) They leave together.

Leaving: -
 Facilitation: Yes
 Co-participation: Yes (joint co-editing)

Instance: 6 (12:46-16:50)
 Instrument 3
 Participant(s) description: Man (face not visible) (P10).

Approaching: P10 approaches instrument while the pattern of previous player still running (open musical figure, 8 beats long).

Playing techniques and interaction:

(12:46) P10 presses some function buttons and 'observes' the pattern at his instrument.
 (13:00) The facilitator (F) approaches him, wipes the grid and shows basic concept with upwards diagonal closed figure.
 (13:25) P10 starts altering the pattern step by step and creates upward and downward closed musical figures, F leaves.
 (14:02) He creates and varies several open musical patterns, then he turns the dial up and holds it (could have been 'picked up' from player at instrument 1 that uses the dial extensively since several minutes).
 (14:30) P10 creates upward-downward closed musical figures and modifies the sound by holding the dial in its positive end position.
 (15:12) P10 'discovers' the loop shift function and in combination with successively shortening the loop length he moves step-wise through the pattern in a rhythmically manner still holding the dial in its positive end position.
 (15:30) Several people stand close to him and observe him playing, P10 creates several combined closed/open figures.

Leaving: P10 is taking out his phone, takes a picture of his instrument and leaves. The instrument is taken over immediately by one of the bystanders.

Facilitation: Yes
 Co-participation: No

Instance: 7 (16:55-17:45)
 Instrument 3
 Participant(s) description: Woman/girl (face not visible) (P11).

Approaching: Before P11 is taking over the instrument, she was watching for around 0.5 min standing close behind player P10 at instrument 3 (Instance 6).
 P11 takes over as soon as P10 leaves (pattern is still running, loop length 8).

Playing techniques and interaction:

(16:55) P11 slightly modifies the set pattern.
 (17:10) At instrument 2, the facilitator demonstrates to a child the use and effect of the sound dial -> P11 starts to use the dial on her instrument: She is slowly turning the dial up and down while modifying the pattern.

Leaving: When P11 is stepping back to take a pictures with her mobile phone, two children immediately take over the instrument. P11 leaves.

Facilitation: No
 Co-participation: No

Instance: 8 (22:12 - M2U00039_Part1(*): 2:20)
 Instrument 3
 Participant(s) description: Man/young adult (P12).

Approaching: P12 approaches Polymetros (all instruments taken) (20:49) and waits standing between instrument 2 and 3 watching the current player. P12 is moving close to instrument 2 and takes over as soon as the player leaves. (pattern of previous player still running, 8 beats long).

Playing techniques and interaction:

(22:12) At first, P12 wipes all notes. Then, starting from a single note, P12 successively adds notes one the same pitch while letting each pattern play for several times before adding a new note.
 (*0:07) A child is approaching and sets some notes on his grid, then turns to watch player on instrument 1.
 (*0:32) P12 touches the dial and turns it just slightly (too less affect the sound).
 (*0:44) He is continuing to edit the pattern in the same manner (letting each new variation play for a few times before changing it) and edits the loop length. He creates several open figures using all eight steps, then he creates a simple two note figure and transposes it down successively.
 (*1:13) Leaving a four notes figure play, P12 tries out the different functions controlled by the buttons on the left applying pitch shifts, tempo changes and loop shifts.

Leaving: While P12 is editing, another audience member (a man he does not appear to know) starts to turn the dial on his instrument and sets some notes. P12 steps back from the instrument and leaves short after.

Facilitation: No
 Co-participation: No

Instance: 9 (9:00 - 15:48)
 Instrument 3
 Participant(s) description: Group of friends (young adults, two male, one female) (P13, P14, P15).

Approaching: The pattern of the previous player is still running (loop length 8)

Playing techniques and interaction:

(9:00) The group tries out different functions together, then P13 explains 'how it works' to his peers: P13 lets a 5 beat figure play and follows the pattern with his finger pointing at the played notes in time.

(9:26) P14 as well as P13 touch the dial and turn it just slightly (too less affect the sound).
 (9:40) P13 switches the tempo to slow while continuously indicating the notes played and sings along to vocalise the phrase played on the instrument.
 (9:46) P13 then sets the loop length to 4 and wipes all notes on the grid, then the group (all three of them) co-edit on the grid, they continuously discuss their playing and each of them tries out different functions of the instrument.
 (11:05) It seems that P14 did not understand the interface concept yet -> P13 is resetting the whole grid and successively builds up a closed musical figure (upwards 'stair-like' pattern where each 'stair step' consists of two identical notes), he successively increases the loop length (4 to 6 to 8).
 (11:30) The group continues co-editing while P13 remains most active.
 (13:35) P13 turns the dial and holds it up and down (likely to be 'picked up' from the facilitator playing on instrument 1 making extensive use of the sound dial at the same time).
 (14:05) The group continues co-editing (all three contributing rather equally), then they leave.

Leaving: -
 Facilitation: No
 Co-participation: Yes (joint co-editing)

Instance: 10 (13:00 - 16:20)
 Instrument 3
 Participant(s) description: Young woman, later joined by man (presumably boyfriend) (P16, P17).

Approaching: P16 approaches the installation while all instruments are taken and closely watches group of players on instrument 2 (Instance 9) for several minutes.

Playing techniques and interaction:

(15:07) When P17 arrives (the group on instrument 2 is still playing) P16 seems to explain to him 'how it works' pointing towards the interface and indicating the pattern played rhythmically (both still observing).
 (15:48) When the group on the instrument leaves, P16 and P17 'stick around the instrument' for around half a minute, taking a step back from the table still discussing, but do not take over to play.

Leaving: -
 Facilitation: No
 Co-participation: -

Instance: 11 (23:05 - 26:00)
 Instrument 3
 Participant(s) description: Teenager (male) (P18).

Approaching: Previous pattern still playing (loop length 4), no players on the other instruments.

Playing techniques and interaction:

(23:05) P18 addresses the facilitator (F): 'What is this?'. F explains the basic concept using a closed liner figure and shows him how to change the loop length.
 (23:50) P18 extends loop length to 8 steps and creates several open figures. Then he deletes all notes and builds up successively combined closed musical figures letting each new 'iteration' play at least once before adding/chancing a note.
 (24:35) He asks F across the table: 'Can I go higher?'. F indicates pitch range buttons. P18: 'Ah!'. He continues editing by building combined open/closed figures.

Leaving: Directed to F: 'Thanks. Nice to meet you. Next time I will bring a couple of classmates with me'.

Facilitation: Yes
 Co-participation: No

File: M2U00039_Part2
 Date: 12.05.2013
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Instance: 12 (1:29 - 13:40)
 Instrument 1/2
 Participant(s) description: Two girls (16-20) (P19, P20).

Approaching: P19 and P20 approach instrument 1 together (grid is reset, loop length 3), instrument 2 is not taken, instrument 3 taken by father with young child.

Playing techniques and interaction:

(1:29) P19 is starting to edit, P20 is watching her, then P19 moves to instrument 2 and P20 is taking over instrument 1.
 (1:40) The facilitator indicates the basic concept of the loop-based interface by pointing along with the phrase played on their instruments (first P19, than P20).
 (3:00) While both continuing playing on their instruments they keep communicating verbally across the table, P19 turns the dial slightly (too less affect the sound).
 (3:25) A child is approaching and stands closely to P20 facing her instrument. She takes a step aside and the child starts to edit. After a short moment, she leaves instrument 1 and joins her friend on instrument 2.
 (3:34) There, P19 and P20 continue to co-edit jointly. They successively try out different function buttons of the instrument. They continue co-editing for another 10 min (most of the time interface obscured by facilitator).

Leaving: -
 Facilitation: Yes
 Co-participation: Yes (joint co-editing)

Instance: 13 (12:30 - 18:00)
 Instrument 3
 Participant(s) description: Couple (25-35), woman (P21), man (P22).

Approaching: P21 and P22 arrive at the installation whilst all instruments are taken (12:00). They stands close to instrument 3 and watches a couple co-editing. When they leave, P21 and P22 take over the instrument (previous pattern is still playing, loop length 8).

Playing techniques and interaction:

(12:30) P21 resets all notes and stepwise creates a closed musical figure (diagonal upwards), she alters it into a straight closed musical figure letting each permutation play for at least one time.

(13:15) P21 creates various closed up and down patterns. While she is editing the pattern, P22 tries out several function buttons on the left-hand side. Each time, she pushed his hand off the controls (4 times) and starts trying different function buttons by herself.

(13:48) When instrument 2 becomes available, P22 takes over the free instrument while P21 remains playing on instrument 3.

(13:56) P22 'discovers' chancing the loop length via the top button row -> he bends over the table and sets the woman's (P21) loop length from 5 to 8 steps. She immediately resets it to 4. She continues creating closed musical figures letting each permutation play for at least one time. She is varying the loop length dynamically and creates more and more open musical figures.

(16:22) P21 creates alternating patterns and uses the loop shift function to dynamically 'move' a small section (2 beats) over the alternating pattern and creates several closed musical figures while dynamically chancing the pitch.

Leaving: P21 picks up her smartphone from the table, takes a close look at it, and turns sideways from the instruments. The instrument is taken over immediately by two bystanders. She approaches P22 who is still playing on instrument 2 and addresses the facilitator saying: 'Very nice.' and reaches for the man's hand as indication to leave.

Facilitation: No
Co-participation: Yes

Instance: 14 (20:50 - M200040_Part1(*) 12:00)
Instrument 3
Participant(s) description: Young woman (P22).

Approaching: P22 approaches instrument 3 with the pattern of the previous player still running (loop length 7), the other two instruments are in use and the table is densely surrounded by a number of bystanders.

Playing techniques and interaction:

(20:50) P22 presses a few function buttons and then addresses the facilitator (F) standing on the other side of the table asking: 'How to play it?'

(21:05) F deletes all notes and shows the basic concept by stepwise creating a closed musical figure (diagonal upwards) and demonstrates how to change the loop length.

(21:50) P22 starts editing creating combined open figures, then she step-wise re-organises her pattern creating closed musical sections and then creates an 8 beat 'straight line' pattern.

(22:57) P22 transposes the pattern stepwise, letting each alteration play for one time. She continues with this playing style creating mainly closed musical figures. She creates alternating patterns and stepwise transforms it into closed line and vice versa. She takes a picture and continues editing (mainly closed musical figures and alternating patterns).

(*7:22) P22 looks up from the instrument and observes the player on instrument 2 who extensively uses the loop shift function to dynamically move a 3 beat long section across the grid. Having played so far without changing the loop length for 11min, she sets the loop length to 3 (like player on instrument 2) and starts to use the loop shift function in a similar way. She also turns up the the Sound Dial and holds it as player on instrument 2 does. She starts to use the Sound Dial dynamically alternating between holding it down and holding it up.

Leaving: A couple approaches instrument 2 (previous player left), P22 steps away from her instrument and shows them 'how it works' and her instrument gets taken over by someone else and she 'sticks around'. As soon instrument 3 is free again, P22 takes over the instrument and plays for another 15min. Then Polymetros has to be stopped temporarily due to a performance -> P22 leaves.

Facilitation: Yes
Co-participation: No

Instance: 15 (18:00-22:00)
Instrument 3/Instrument 2
Participant(s) description: Couple (20-25), woman (P23), man (P24).

Approaching: P23 and P24 stand in some distance to the table (~1.5m). When player on instrument 3 (Instance 13) takes a step sideways, they take over the instrument (the previous pattern is still playing, loop length 8).

Playing techniques and interaction:

(18:00) P23 makes several note edits and together they trying several function buttons while discussing. It appears that they did not yet figure out how the loop-based interface as she inputs notes rhythmically.

(19:35) They step away from the instrument and the table but return after around 20 seconds. P23 is going back to instrument 3, while P24 takes over instrument 2 (loop length 4).

(19:55) P23 stands close to instrument 3 but is not touching it, P24 starts to edit on instrument 2. After a short while, P23 moves to instrument 2 as well. P24 sets single notes sparsely at first, letting each new edit play at least for one time. Then, he 'joins' the single notes together creating various closed musical figures (various up-down and diagonal patterns and combinations of them).

Leaving: -
Facilitation: No
Co-participation: Yes (mainly P24 editing)

Instance: 16 (11:00 - 12:10)
Instrument 3
Participant(s) description: A group of four, two young women (P25, P26), two young man (P27, P28).

Approaching: The group approach instrument 3 together while previous pattern is still playing.

Playing techniques and interaction:

(11:00) P25 inputs several notes with two fingers while mainly facing her three friends rather than the interface.

(11:28) P25 takes out her mobile, walks to the other side of the table to take some pictures.

(11:40) P26 and P27 setting several notes on the interface but seem not to understand the loop-based concept doing it in a very quick and 'random' manner. Both touch the dial moving it just a very small amount.

(12:10) P26 and P27 leave (their friends (not visible) seen to have already moved on)

Leaving: -
Facilitation: No
Co-participation: Yes

Instance: 17 (22:55- 24:20)
Instrument 2
Participant(s) description: Male (25-30) (P29)

Approaching: P29 approaches instrument 2 whilst the previous pattern is still playing (loop length 8).

Playing techniques and interaction:

- (22:55) P29 starts trying several function buttons. He bends down with one side of his head towards the instrument listening from where the sound is coming.
(23:23) P29 tries the dial (Player on instrument 3 is using it at the moment too). He makes some note edits but seems to not having understood the loop based approach.
(23:38) He steps back from the instrument but remains close to the table watching the other players.

Leaving: P29 remains watching for several minutes until the curator asks to stop Polymetros for the time of a performance in the adjacent room.

Facilitation: -
Co-participation: -

File: M2U00040_Part2
Date: 12.05.2013
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Instance: 18 (9:40 - 12:38)
Instrument 3
Participant(s) description: Young woman (P30).

Approaching: P30 approaches instrument 3 while previous pattern is still playing (loop length 5).

Playing techniques and interaction:

- (9:40) At first, P30 makes several note edits in the inactive section of the grid (no effect). Then she deletes all notes on the grid.
(10:15) Someone standing behind her (not visible to the camera) reaches over and sets her grid to 8 steps.
(10:20) P30 starts creating a closed alternating pattern, deletes all notes before creating a new pattern (closed figure diagonal upwards). She follows the pattern with her finger, then she creates various variations of mainly closed musical figures.
(11:40) P30 creates several straight and alternating patterns that she then transposes several times.

Leaving: Before she leaves she tries to deactivate all available steps of the grid.

Facilitation: No
Co-participation: no

Instance: 19 (12:15 - 13:50)
Instrument 2
Participant(s) description: Young man (18-25) (P31).

Approaching: P31 approaches instrument 2 with the previous pattern still running (loop length 8).

Playing techniques and interaction:

- (12:15) P31 re-organises the playing pattern into a straight closed musical line and then step-wise into an upwards diagonal.
(12:41) P31 touches and turns the dial slightly (too less to affect the sound). He creates a 'stair-like' pattern where each 'stair step' consists of two identical notes, and straight and diagonal (downwards) closed musical figures.
(13:15) P31 turns around towards the LCD-screen that shows the showreel video, takes the headphones and watches the video.

Leaving: After watching the video for a short while P31 turns around and steps back towards the table. His instrument has been taken over by another player (the other two are occupied as well). He waits for around half a minute, then leaves.

Facilitation: No
Co-participation: No

Instance: 20 (13:20 - 14:20)
Instrument 2
Participant(s) description: Male teenager (P32).

Approaching: P32 is standing close to an active player and takes over the instrument as soon as he is stepping away (previous pattern is still playing, loop length 8).

Playing techniques and interaction:

- (13:20) P32 quickly sets notes in a 'random' manner across the grid and it appears that he did not understand the loop-based interface concept.
(13:40) P32 slightly turns the dial (too less to affect the sound) and continues with quick, 'random' input.

Leaving: -
Facilitation: No
Co-participation: No

Instance: 21 (12:40 - 15:40)
Instrument 3
Participant(s) description: Woman (P33).

Approaching: P33 approaches and stands close instrument 3 that is in use (12:20) and takes over as soon as the previous player is leaving (previous pattern is still playing, loop length 3).

Playing techniques and interaction:

- (12:40) After pressing some function buttons on the left, P33 'quite determinedly' extends the grid to 8 steps (its likely that she picked that up from player before, who extensively used the loop length buttons on the top while she was waiting) and deletes all notes.
(13:04) P33 starts with a diagonal closed line (downwards) and indicates each played note with her hand. Before creating another pattern, she deletes all notes which she does repeatedly.
(13:50) P33 appears to 'systematically' explore the functions on the left. She creates a short closed musical figure, lets it play a few times following with her fingers and then tries the different buttons. She applies tempo change, pitch shift (switching back and forth between octaves several times) and loop shift. Then she uses these function 'together' in combination changing loop length, pitch and tempo in a 'dynamic' manner.

Leaving: -
Facilitation: -
Co-participation: No

File: M2U00041
Date: 12.05.2013
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Instance: 22 (25:40 - 27:40)
Instrument 3
Participant(s) description: Young woman (P34) and man (P35).

Approaching: P34 and P35 approach instrument 3 together (previous pattern is still playing, loop length 4).

Playing techniques and interaction:

(25:40) P34 deletes all notes and they start co-editing on the grid. P35 sets a pattern and follows the played notes with the finger. P34 resets the grid for several times.
(26:20) P34 leaves to take over instrument 1. P35 remains playing.
(26:30) P35 slightly turns the dial (too less to affect the sound). He creates a closed musical figure and tries different function buttons.
(27:05) By using the loop-shift function, P35 reduces the active section to one beat and shifts it left and right on the grid playing step-wise through the set pattern.

Leaving: It appears that P35 does not know how to re-size the 1 beat long active selection (did not 'discover' the loop length buttons of the top row). He tries several function buttons on the left and then left the instrument to join P34 who is still playing on instrument 1.

Facilitation: -
Co-participation: Yes (joint co-editing)

File: M2U00042_Part1
Date: 17.05.2013
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Instance: 23 (10:19 - 12:20)
Instrument 3
Participant(s) description: A group of friends, two male (P36, P37) , two female (P38, P39).

Approaching: The group approaches Polymetros while none of the instruments is in use and all grids are wiped.

Playing techniques and interaction:

(10:19) They all gather around instrument 3 and observe the interface and appear to be 'not quite sure' what to do.
(10:57) The facilitator indicates the loop based concept creating a four note pattern and pointing out the played notes.
(11:05) They start co-editing together. P36, who is most active editing, points to instrument 2 and it appears she asks her friends to take over the other instrument -> P38 does.
(11:35) Editing alone from now on, P36 is creating open musical figures and several alternating patterns (P37 and P39 only watch). Then all three leave. P38, who took over instrument 2, continues playing but leaves his instrument when he becomes aware that his friends have left.

Leaving: -
Facilitation: Yes
Co-participation: Yes (joint co-editing)

Instance: 24 (15:00 - 16:40)
Instrument 3
Participant(s) description: Young woman (P40), joined by a man later (P41).

Approaching: P40 is approaching instrument 3. No notes are set on the grid (loop length 8).

Playing techniques and interaction:

(15:00) P40 sets some notes, but appears to have not understand the loop based concept yet.
(15:15) The facilitator approaches her and sets the loop length to 4 and creates closed musical figure (diagonal up) indicating the played notes with his finger.
(15:20) P40 'outbursts': "Ohh!" when she 'gets it'. In the meantime P41 (who apparently knows her) approaches and stands close to her next to the instrument.
(15:36) P40 extends the grid to 8 and creates several closed musical figures (diagonal, straight). After each pattern, she resets all notes before creating a new one.
(15:56) P41 reaches over and modifies the loop length -> P40 takes a step aside (16:00) and P41 is taking over the instrument.
(16:10) A woman at instrument 1 starts to explains Polymetros loudly in Chinese to her friend while pointing to the other instruments. This 'demonstration' immediately gathers a group of passers-by around the table. P41 stops editing. P40 and P41 leave the instrument which is immediately taken over by a by-stander close to them.

Leaving: -
Facilitation: Yes
Co-participation: Yes

File: M2U00042_Part2
Date: 17.05.2013
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Instance: 25 (16:47 - 21:00)
Instrument 2/3
Participant(s) description: Group of three, two female (P42, P43), one male (P44).

Approaching: The group approaches the table whilst the facilitator (F) demonstrates loop based concept to player on instrument 1. They watch for a while and then move to instrument 2 which is free (grid wiped, loop length 4).

Playing techniques and interaction:

(16:47) They start co-editing and create closed musical figure (diagonal upwards) (the same figure that F used for demonstration on instrument 1).
 (17:25) Then they create several closed musical figures (mainly P42 and P43 co-editing) and apply different functions (pitch changes, loop length variation). P44 turns around and watches the video showreel, then he turns back to the women and points to the LCD screen -> P43 turns around as well and they watch the video together. P42 continues playing.
 (18:05) Then P43 and P44 return to the instrument. The P42 and P43 continue co-editing. When instrument 3 becomes free the group splits.
 (18:40) P42 stays at instrument 2, P43 and P44 take over instrument 3 (previous pattern still running, loop length 5).
 (18:46) P43 and P44 co-edit on instrument 3 creating open musical figures and stepwise increase the grid length to 8.
 (19:10) P43 returns to her friend at instrument 2 while P44 remains at instrument 3.

Leaving: Due to a software failure the instruments' grids 'freeze' for a moment (19:25) and they take a step back while the facilitator resets the three grids. When the system runs again 'their' instruments are immediately taken over by other audience members. The groups stay for a while watching, then leaves.

Facilitation: Yes
 Co-participation: Yes (joint co-editing)

B.3 Interview with Curator

File: 采访.m4a

Duration: 08:00 min

Start of transcript: 01:08 min

Date: 15.05.2013

Interview with Curator Wenjin Yao [R]

I: What was the general motivation to organise this exhibition?

R: Actually, I had no exact idea about people's understanding of interaction design here and therefore I wanted to do such work and have a look. You know, in the recent seven years I stayed in France and London where I did design research as well and so I know about the standards and general understanding of design in Europe. But in China, when talking about design, most people think about design only in terms of designing appearances and have no understanding, for example, of designing for experiences.

I: Apart from interactive art as shown at the exhibition, how common is public interactivity in other contexts? I think for example of museums or science centres in Europe where interactivity is more and more common?

R: No, I think this whole area is really really new in China. And as far as I know there has been only one exhibition about interactive design and art so far, I think it was two years ago at Beijing's National Gallery.

I: So not just in the context of art but in general, hands-on interactive experiences are still very rare?

R: Yes, definitely, the people are not used to such things here.

I: On the other hand, however, it seems many people are very used to interactive devices such as smart phones and tablets.

R: Yes, that is mainly related to the commercial side, mainly telecommunication, and the effects of globalisation - so for example many people [in China] use the iPhone now.

I: So what do you think about the future of interactive art and design here in China?

R: I think for now, rather than focusing on the general public, I really want to focus on the people in the design area first. From my perspective, even the understanding of interaction of people in this professional area still has a distance from the understanding in Europe and other Western countries. Therefore, my current focus is on this group and will maybe later the focus will shift to the general public.

I: So what were the reactions of the people you came in contact when organising this exhibition - such as for example the sponsors - and how did you explain the concept and what you are going to organise?

R: I think the advantage here was my communication technique, informed by my research on Chinese culture, which for example also includes things like behaviour or the Chinese way of communication. So I think one particular interesting example is that when we talk about innovation in Western countries people ask you: Has this been done before, while he or she wants that it hasn't as this means it is totally new. But in China if people ask you this they want to make sure that it has been done before as this means it will be safe. So when I talked to the people here about this exhibition I explained that I will bring exhibits together that have been shown before for example in London or elsewhere and had very good feedback. For example I mentioned that your work has been exhibited in the V&A Museum in London, where you know that this is a very famous museum and a high level of presentation.

I: So you did have to overcome some scepticism at first?

R: Well yes, they set me a standard they wanted me to meet which was firstly, this has to be new for a

Chinese audience and secondly, it has been proven to be very successful in Western countries before.

About the Curator [R]

Wenjin Yao curated and coordinated the 'Design Can Change' exhibition in cooperation with the Media Lab (Shenzhen) of Hunan University and the OCT-Loft creative group. She holds a BA degree in Industrial Design from Nanjing University of Aeronautics and Astronautics, China and a MA from Arts et Métiers ParisTech (ENSAM), France, where she majored in Virtual Reality and Innovation. She worked as a structural engineer and an industrial designer. She obtained a PhD from the Royal College of Art, London, where she conducted design research on Chinese Culture and contemporary design.

Appendix C

Study III Materials

C.1 Questionnaire [Spanish, English]

Edad:
 Sexo: ☐ femenino ☐ masculino

Como consideras tu capacidad musical?
 ○ ○ ○ ○
 ninguna principiante intermedio semi-profesional profesional

Qué tipos y géneros de música te gustan más : _____

Si eres músico, por favor especificas tu profesión : _____
 (por ejemplo: DJ, productor, pianista, cantante,...)

Por favor, explicas como las siguientes frases se aplican con tu experiencia en usar Polymetros?

Me he sentido parte de un proceso creativo.
 ○ ○ ○ ○ ○
 para nada poco regular bastante muchísimo

Me he sentido en control.
 ○ ○ ○ ○ ○
 para nada poco regular bastante muchísimo

Me he sentido conectado con los otros compañeros.
 ○ ○ ○ ○ ○
 para nada poco regular bastante muchísimo

Ha sido exigente.
 ○ ○ ○ ○ ○
 para nada poco regular bastante muchísimo

Me gustas la música que hemos criado.
 ○ ○ ○ ○ ○
 para nada poco regular bastante muchísimo

Mi creación ha sido influida por la música de los demás.
 ○ ○ ○ ○ ○
 para nada poco regular bastante muchísimo

Recomendarías tocar Polymetros a mis amigos.
 ○ ○ ○ ○ ○
 para nada poco regular bastante muchísimo

[FRONTSIDE]

Si tienes alguna sugerencia, por favor compártelas con nosotros : _____

Información para los participantes:

Polymetros es parte de un proyecto de investigación que examina estrategias de diseño para sistemas colaborativos e interactivos que se dirigen a un público amplio. Y quiere también promover la creatividad pública y la colaboración musical.

Explicándonos de tus experiencia con Polymetros, nos ayudas en evaluar nuestro procedimiento y participarás en el futuro de nuestra investigación.

Por favor, no dudes en preguntar si alguna cosas están poco clara o si te gustaría saber más.

Deducción de aprobación:

Apruebo que el proyecto de investigación me ha sido explicado bien. Además consiento mi participación en el proyecto y a el proceso de mi información personal para el objetivo de este proyecto.

Entiendo que esta información estará tratada de confidencia y en concordancia de las provisiones del Data Protection Act 1998.

Signatura: _____ Fecha: _____

Queen Mary Research Ethics reference number: 1201

[BACKSIDE]

Your age: Your gender: ☐ female ☐ male

How would you rate your musical proficiency?

☐ none ☐ beginner ☐ intermediate ☐ semi-professional ☐ professional

What type and genre(s) of music do you like the most : _____

If you are an active musician, please specify what you do : _____
(e.g. DJ, producer, pianist, singer...)

Please indicate how the following statements apply to your experience playing Polymetros:

I felt part of a creative process.

☐ not at all ☐ slightly ☐ moderately ☐ fairly ☐ very much

I felt in control.

☐ not at all ☐ slightly ☐ moderately ☐ fairly ☐ very much

I felt connected to the other players.

☐ not at all ☐ slightly ☐ moderately ☐ fairly ☐ very much

It was challenging.

☐ not at all ☐ slightly ☐ moderately ☐ fairly ☐ very much

I liked the music we created.

☐ not at all ☐ slightly ☐ moderately ☐ fairly ☐ very much

My playing was influenced by the playing of the others.

☐ not at all ☐ slightly ☐ moderately ☐ fairly ☐ very much

I would recommend playing Polymetros to my friends.

☐ not at all ☐ slightly ☐ moderately ☐ fairly ☐ very much

[FRONTSIDE]

If you have any other feedback for us please share and let us know : _____

Information for participants:

Polymetros is part of a research project that investigates design strategies for collaborative interactive music systems that reach out to broad audiences and foster public creativity and collaboration. Our research aims to inform the design of future interactive music environments for immediate musical collaborations.

Telling us how you experienced Polymetros allows us to evaluate our approach and will inform the future directions of our research.

Please ask if there is anything that is not clear or if you would like more information.

Consent statement:

I agree that the research project has been explained to me to my satisfaction and I agree to take part in this study.

I consent to the processing of my personal information for the purposes of this research study.

I understand that such information will be treated strictly confidential and handled in accordance with the provisions of the Data Protection Act 1998.

Signed: _____ Date: _____

Queen Mary Research Ethics reference number: 1201

[BACKSIDE]

C.2 Musical Genres: ‘Other’

Genres stated five times or less at item S2:

5x: Reggae, Jazz, Deep House, Progressive

4x: Bass Music, Alternative

3x: Trance, Soul, IDM, Dance, Dub, Electro Pop

2x: Hard Techno, World Music, Tech House, Salsa, Electro Swing, Garage

1x: Trip Hop, Ska, Rumba, R&B, Nu Disco, Noise, Latin, Industrial, Indian, Folk, Emo, Electro Latino, Electro Indie, Electro Glitch, Dream Pop, Down-tempo, Disco, Classic Rock, Breakcore, Blues, Acid Jazz, Acid

C.3 Musical Activities: ‘Other’

Musical activities stated nine times or less at item S3:

9x: Pianist

8x: Guitarist

7x: Singer

4x: Drummer, keyboard player, percussionist

3x: Composer

2x: Dancer, bass player

1x: VJ, sound designer, performer, singer-songwriter, live performer, sampling artist, professor, musician, MC, laptop performer, instrumentalist, contemporary performer

C.4 Free-text Responses

Categorised responses for item Co (in chronological order)
Specified by 49 of 221 respondents

Categories:

Commendatory feedback
Suggestions for improvement
Suggestions of use

[t] translated from Spanish

- It's similar to the Yamaha's tenori-on. Love it!
- cool machine!
- it'd be great/nice/fun/perfect/interesting to be able to play different instruments for different players like in a band :) Nice work!
- you could have some headphones, it would be nice to have sounds from different instruments [t]
- ∞! More control over loop length, nice design, looks friendly
- more control over the timbre of the sound. Otherwise, lots of fun
- very nice
- A bit more of control. Great idea anyway :)
- great fun
- better in the techno mode!
- more steps 16!
- volume control
- I wonder if it is expandable - more sounds etc.
- that's a product to be sold :)
- would be amazing if the colour in the big orb can change according to the music, or if it can reflect the pitch/speed of the music produced
- pattern recording
- different sounds, not just transposition
- it would be fun to demonstrate such a powerful instrument in schools, universities and conservatoires due to its results and the way it works [t]
- luv it!
- more timbres and loops, special rows for bass, synth, arpeggiator
- change of sounds and more control of the tempo [t]
- big up congrats
- that you could hear better we are missing a pair of headphones for each player [t]
- for children at school!! [t]
- 4 da people
- nice work, fun.
- interactive linked music
- more volume control [t]
- have a small display??
- for competitions of group music-making [t]
- would be great to have some visual interaction as well: visualising notes, signals, etc. Also, a tool that can help upload song to the web, then share.
- awesome! so much fun
- sell it! :)
- more volume, more people + variety
- more oscillators
- more drums and percussion [t]
- so much enjoyable
- ask/suggest people to play together
- This is amazing. The opportunity of try different kind of instruments for free is the best way to contribute to music's grow. Thank you for what you do. :)
- the control of the decay should be faster, the FAST tempo took a while to synchronise [t]
- would be an excellent tool in hospital for long term hospitalised children, for their developmental process, especially if bedbound would help them socialise
- great fun
- thanks, great experience
- great fun, perhaps more control over the individual sounds and their volume level
- very interesting
- effects!!! delays, reverbs..
- very nice
- it's fun
- very intuitive

C.5 Video Annotations

File: M2U00045.MPG
Date: 13.06.2013
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Instance: 1 (0:04 - 2:42)
Sound set: I
Instrument 1
Participant(s) description: Two man (25-30) (P1, P2).

Approaching: P1 approaches the installation and takes over instrument 1 that just became available (previous pattern still running, loop length 8).

Playing techniques and interaction:

- (0:04) P1 starts by trying out different buttons and the dial in an 'exploratory' manner.
(0:18) P1 'discovers' how to change the playback speed and switches between fast and slow for several times, before he tries out the pitch shift and loop shift functions.
(0:57) P1 reorganises the notes into a closed musical figure (straight line), sets the tempo to slow and creates several variations. He turns the Sound Dial and holds it in its positive end position for a moment.
(1:26) P1 wipes the grid and sets a single note when he is approached by P2. P1 starts explaining to him 'how it works': P1 creates a closed musical figure (diagonal downwards) and illustrates the loop-based playback by following the pattern with his hand.
(2:02) P1 then wipes the grid and sets a single note. When this note is played, he points it out to P2.
(2:20) When P2 leaves, P1 continues playing by creating mainly closed musical figures.

Leaving: P1 is approached by a woman holding a festival program, after a short conversation, they leaving together.

Facilitation: No
Co-participation: Yes (explanation to companion)

Instance: 2 (2:44 - 4:30)
Sound set: I
Instrument 2
Participant(s) description: Two men (40-45) (P3, P4).

Approaching: P3 arrives at the installation just at the moment when all previous players leave and all instruments are wiped remotely by the facilitator.

Playing techniques and interaction:

- (2:44) After looking at instrument 2 for a moment (with hands in his pocket), P3 turns towards the poster at the side wall of the booth. Then he walks around the installation and picks up and reads the Polymetros flyer with a short project description. When instrument 1 is taken over by an audience member, P3 turns towards him and watches him for a short while, then he approaches instrument 2.
(3:20) When P3 takes over instrument 2 he is joined by P4 who was walking past the booth. Simultaneously, they try different functions and set notes in a rather 'arbitrary' manner.
(3:50) P3 appears to 'grasp' the loop-based concept and points along the pattern in accordance with its playback.
(3:55) P4 leaves the instrument. P3 tries out different function buttons in a more systematic manner and shifts the pitch of the playing pattern up and down for several times.
(4:00) P3 starts reorganising the pattern on the grid into a closed musical figure (diagonal up/down) and creates variations of it.

Leaving: -
Facilitation: -
Co-participation: Yes

Instance: 3 (5:00 - 6:55)
Sound set: I
Instrument 2
Participant(s) description: Two men (25-30) (P5, P6).

Approaching: P5 arrives at the table whilst all instruments are taken. He steps close to the table and observes the active players. When the players at instrument 2 leave, P5 takes over the instrument (previous pattern still running, loop length 8).

Playing techniques and interaction:

- (5:15) P5 tries several function buttons and then successively deletes the notes on the grid.
(5:45) P5 starts to step-wise create a closed musical figure (diagonal up and down) and changes the playback speed several times.
(6:00) P5 is joined by P6 and starts to explain how the instrument works: With his hand upright, P5 illustrates the loop-based playback by following the pattern for several times ('chopping' gesture), and then demonstrates how to change the pattern while P6 presses several function buttons. Then P6 steps away to take over instrument 3. P5 continues playing.

Leaving: P5 steps away from his instruments and turns towards P6 playing on instrument 3. After a short conversation, both leave.

Facilitation: No
Co-participation: Yes (explanation to companion)

Instance: 4 (7:12 - 10:20)
Sound set: I
Instrument 2
Participant(s) description: Couple (35-40) (P7, P8).

Approaching: P7 and P8 arrive at Polymetros when all instruments are available, all note grids are wiped.

Playing techniques and interaction:

- (7:12) P7 presses the same note button several times, both seem not sure 'what to do'.
(7:20) P7 makes eye contact with the facilitator (F) standing on the other side of the table. F deletes all notes and demonstrates the loop-based concept by stepwise creating a closed musical figure.
(7:44) P7 makes some edits to F's pattern before he deletes all notes and starts 'from scratch'. F leaves.
(8:00) While P7 remains on instrument 2, P8 takes over instrument 3.

(8:14) P6 deletes all notes on his instrument and signals P7 on instrument 3 to start. A moment after P8 started playing, P7 'joins in' while repeatedly looking at her instrument.

(8:40) When a player takes over instrument 1 (not in use in this instance so far), P7 points towards him and comments to P8 that "he [the new player] is the bass".

(9:00) During their playing, P7 and P8 continue to chat to each other across the table and take pictures of each other playing.

Leaving: When P7 becomes aware of a young woman standing close to him observing, he makes an inviting gesture towards her and steps back from the instrument.

Facilitation: Yes
Co-participation: Yes (co-participation at first, then splitting up to individual instruments)

Instance: 5 (10:00 - 11:55)

Sound set: I

Instrument 2

Participant(s) description: Two men (30-35) (P9, P10).

Approaching: P9 and P10 arrive at the installation whilst all instrument are in use. They stand at some distance (~2m) chatting to each other and occasionally looking towards the table. When the player on instrument 2 leaves, they approach the instrument (previous pattern still running, loop length 6).

Playing techniques and interaction:

(10:30) P9 adds several note to the existing pattern and then 'reorganises' all notes into a straight line.

(10:50) In conversation with his friend, P9 stepwise alters the pattern, letting each variation play for at least one time while following the played notes with his finger.

(11:10) P10 steps back from the instrument, watches the other players, and then leaves (11:30). P9 continues playing creating mainly open and closed musical figures.

Leaving: P9 looks around and briskly leaves his instrument, presumably following his companion.

Facilitation: No

Co-participation: Yes (mainly P9 editing)

Instance: 6 (28:10 - 30:40)

Sound set: I

Instrument 1

Participant(s) description: Two young man (20-25) (P11, P12), part of a group of four.

Approaching: The group approach Polymetros whilst all three instruments are in use and stays close to the table between instruments 1 and 2 observing the current players. When the player on instrument 1 (elderly man) notices the waiting group, he orients himself towards the group and makes an inviting gesture towards the instrument (28:45). He then steps back and leaves. P11 and P12 take over the instrument (previous pattern still running, loop length 7).

Playing techniques and interaction:

(28:50) At first, P11 and P12 collaboratively delete all notes of the previous pattern.

(29:00) P11 starts to create a new pattern. When P12 tries to contribute notes as well, P11 pushes his hand aside. P11 creates several 'sparse' patterns, chancing one note per playback cycle.

(29:25) P11 steps back from the instrument and, together with another member of the group of four, leaves the installation. At first, P12 appears to consider following his companions, but then reconsiders, steps back and takes over the instrument.

(29:55) P12 tries out several functions (loop-shift, pitch-shift) and then uses them in combination.

Leaving: When the forth member of the group leaves the installation as well, P12 leaves the instrument and follows.

Facilitation: No

Co-participation: Yes

Instance: 7 (29:40 - 33:10)

Sound set: I

Instrument 3

Participant(s) description: Man (25-30) (P13).

Approaching: P13 arrives at the installation and immediately takes over instrument 2 (note grid wiped, loop length 6).

Playing techniques and interaction:

(29:45) At first, P13 turns the dial (no effect, as no notes set). P13 then successively tries out several functions and apparently 'figures out' the instrument.

(30:05) After creating a two-note figure (loop length 4), P13 puts his right hand on the dial (which will keep hold of the dial for the whole playing instance). P13 turns the dial several times between its positive (sound gets brighter/more resonant) and negative (sound gets shorter/more percussive) end position in rapid succession.

(30:20) P13 starts using the dial in more 'dramatic' manner: From its negative end position, he very slowly turns the dial to the right and back again, causing a change in sound that resembles a 'filter sweep' as common in electronic dance music.

(30:40) P13 continuous with this combined interaction style for the following 2.5 minutes: While editing the pattern with his left hand, he dynamically changes the sound via the dial with his right hand. Temporarily, he holds the dial in its positive or negative end position to keep the sound either percussive or resonating while editing the patten. His overall posture (bent forward over instrument, moving to the beat) and 'performative' dial use are reminiscent of an electronic music DJ or live performer.

Leaving: -

Facilitation: No

Co-participation: No

Instance: 8 (30:50 - 33:15)

Sound set: I

Instrument 2

Participant(s) description: Young woman (20-25) (P14), and man (prob. boyfriend, 25-30) (P15).

Approaching: P14 and P15 approach instrument 1 together which is taken over by P15. After a short wait by his side, P14 walks to instrument 2 (note grid wiped, loop length 8).

Playing techniques and interaction:

- (31:05) While repeatedly looking at the player at instrument 3 (Instance 7), P14 sets and deletes single notes before creating a 'sparse' two-note pattern. Letting this pattern play, she tries several function buttons and applies several pitch shifts and tempo changes before adding more notes.
- (31:45) P14 turns and holds the dial in its maximum position (potentially 'picked up' from player at instrument 3 (Instance 7) who uses the dial permanently since P14 started playing).
- (31:55) Appearing to be confident with the instrument, P14 creates various 'sparse' patterns and incorporates functions such as pitch shift and variation of loop length into her playing.
- (32:25) After a verbal exchange with P15, she returns to instrument 1. It appears that P15 has not yet understood the loop-based concept of the instrument and asked for advice.
- (32:30) At first, P14 deletes all notes and points out the loop-based playback with her hand while giving explanations. P14 then creates a straight line of notes. P14 seems to have difficulties to 'spot' the instrument in the overall output (it is pitched to the lowest octave range) and guides P15 to 'her' previous instrument to continue her explanation there.
- (32:50) At instrument 2, P14 points out the playback of her previously created pattern to P15 by following it with the finger before she starts editing it.

Leaving: When P15 turns away from the installation, P14 leaves the instrument and both move on.

Facilitation: -

Co-participation: Yes (splitting up to individual instruments, then co-participation)

Instance: 9 (35:20 - 41:15)

Sound set: I

Instrument(s) 1, 2, 3

Participant(s) description: Two men (25-30) (P16, P17), joined later by two companions (male, female, similar age) (P18, P19).

Approaching: P16 and P17 approach instrument 3 together (note grid wiped, loop length 4)

Playing techniques and interaction:

- (35:20) Both immediately appear to 'grasp' the loop-based concept and start co-editing: With one hand (holding a drink in the other) P16 edits note grid and loop length, while P17 tries out the function buttons on the left.
- (36:15) With his free hand, P16 takes hold of the dial and turns it dynamically from its neutral to positive end position for several times while P17 continues editing the pattern.
- (36:30) When instrument 2 becomes available, P16 points towards it signalling P17 to take over the instrument -> P17 moves to instrument 2, P16 remains at instrument 3.
- (37:00) P16 and P17 continue playing on their instrument while occasionally chatting across the table (both partly occluded by an observer standing at the rear of the booth).
- (38:00) While chatting, P16 moves over to P17 at instrument 2 and sets the loop length to one.
- (38:15) P16 returns to instrument 3 and both continue playing on their instruments using all available functions.
- (38:50) When instrument 1 becomes available P16 leaves instrument 3 and takes over instrument 1.
- (39:05) They are joined by P18 and P19 who arrive at the table. P19 positions herself close to P16 at instrument 1. P18 takes over instrument 3.
- (39:10) P17 leaves instrument 2 and attends P18 at instrument 3 and shows him how the instrument works. Instrument 2 is immediately taken over by a by-stander (not part of the group).
- (39:30) At instrument 1, P16 explains the instrument to P19. He points out the loop-based playback with his finger and demonstrates the how to change the loop length and the loop shift function.
- (39:50) P19 starts to co-edit together with P16 at instrument 1.
- (40:15) When instrument 2 becomes available again, P17 moves back to instrument 2 -> the group now has taken over all three instruments.
- (40:30) When P17 steps back to take a picture of the group playing with Polymetros, P16 (currently co-editing with P19 at instrument 1) takes over instrument 2.
- (40:40) While P16, P18 and P19 continue playing on one instrument each, P17 takes a video of the group playing with his mobile phone.

Leaving: Due to a software failure, all instruments 'freeze'. While the facilitator resets the software application, the group leaves.

Facilitation: No

Co-participation: Yes (co-participation, splitting up to individual instruments, explanation to companion)

Instance: 10 (52:40 - 55:10)

Sound set: I

Instrument 1

Participant(s) description: Two men (25-35) (P20, P21).

Approaching: P20 and P21 arrive at Polymetros whilst all instruments are taken. They remain standing at some distance and observe the active players. When two other by-standers who were positioned between instruments 1 and 2 leave, P20 and P21 'fill the gap' and move close to the table. They 'inspect' the sphere in the middle of the table and closely watch the players. When instrument 1 becomes available (53:30), they take over the instrument (note grid wiped, loop length 5).

Playing techniques and interaction:

- (53:45) P20 sets a single note on the first beat of the loop and rhythmically points at it with his finger while P21 starts using the dial turning it alternately in both directions.
- (54:00) P20 stepwise creates a closed musical figure, adding a new note after a few playback cycles.
- (54:25) For the rest of the instance P20 remains in charge of editing. He mainly plays by dynamically changing loop-length and notes while P21 occasionally applies the Sound Dial.

Leaving: -

Facilitation: No

Co-participation: Yes (P20: Note editing, P21: Sound Dial)

Instance: 11 (55:10 - 56:50)

Sound set: I

Instrument 1

Participant(s) description: Young man (18-25) (P22), accompanied by his girlfriend.

Approaching: After standing in the corridor near the installation with his girlfriend, P22 approaches instrument 1 when the previous players leave. His girlfriend remains standing in the corridor focusing on her mobile phone. As the loop length is set to one when P22 takes over the instrument, the facilitator resets the loop length to four and indicates the loop-based playback.

Playing techniques and interaction:

(55:20) P22 starts playing by setting a single note on the first beat of the loop and stepwise transposing it after each playback cycle.
(55:35) P22 then creates several open musical figures, editing them in a rapid and dynamic manner.
(55:45) P22 sets the loop length to 8 and wipes all notes. He creates a 'sparse' pattern and shifts the instrument's pitch into the highest octave range.
(56:00) P22 starts using the Sound Dial and turns it several times to its positive end position (sound gets brighter and more resonant) and back to its neutral position.
(56:20) With his right hand, P22 holds the dial in its positive end position while editing the pattern with his left hand.
(56:30) P22 sets the loop length to two beats and dynamically varies a two-note pattern while continuously modifying the sound dynamically via the dial.

Leaving: P22 leaves with his girlfriend after she approached him to show him something on her mobile phone.

Facilitation: Yes
Co-participation: No

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Instance: 12 (4:50 - 9:50)
Sound set: I
Instrument 1
Participant(s) description: Man (30-35) (P23).

Approaching: P23 arrives whilst all instruments are taken and the installation is surrounded by several by-standers. P23 stays at some distance from the table (~1.5m) between instrument 1 and 2 and observes the player at instrument 2. He takes out his phone and makes a picture (5:20). P23 is about to move on (slowly walking towards the next booth) when he becomes aware that instrument 1 has become available. P23 turns around (5:40) and takes over instrument 1 (note grid wiped, loop length 8).

Playing techniques and interaction:

(6:00) P23 sets a single note and after letting it play for several times, he extends it into a straight line of notes.
(6:20) P23 varies this closed musical figure by 'taking out' some notes of the line, placing them somewhere else on the grid and then putting them back 'in line'.
(7:05) P23 begins to create more complex patterns (mainly open musical figures).
(7:30) P23 starts varying the loop length, and from then on, sticks to rather short patterns (2, 3, and 4 beats).
(8:30) After creating short, 'bass-like' pattern (the instrument is pitched to its lowest range), P23 turns and holds the Sound Dial in its positive end position.
(9:30) P23 'discovers' the mute function: He mutes the bass-like pattern and 'brings it back' again. This action is accompanied by articulate movements of his upper body. These are reminiscent of a DJ who 'cuts the bass' via the equaliser and dramatically 'drops it back in'.

Leaving: -
Facilitation: No
Co-participation: No

Instance: 13 (10:10 - 13:10)
Sound set: I
Instrument 1
Participant(s) description: Man (25-30) (P24), accompanied by his girlfriend (25-30) (P25).

Approaching: P24 approaches whilst the booth is densely packed. Despite the fact that instrument 1 is available, he remains at some distance in front of it (~1m) and takes a picture with his mobile phone. After an inviting hand gesture from the research assistant, P24 takes over the instrument (10:25) (note grid wiped, loop length 8), P25 remains standing in the background.

Playing techniques and interaction:

(10:40) P24 starts by creating mainly open musical figures.
(11:00) P24 reorganises the pattern into a straight line of notes letting it play for several loop cycles. He then alters single notes of the line and places them 'back in line' again.
(11:15) P24 turns towards P25 standing behind him, and with a circular movement of his hand across all three instruments P24 appears to illustrate that they all play together. P25 nods.
(11:20) P24 creates several stairlike patterns (each two consecutive notes have the same pitch), before he reorganises the notes into a closed musical figure (diagonal downwards).
(11:40) Letting the closed figure play, P24 tries out all function button on the left successively.
(12:00) P25, who stepped closer to the instrument, slightly turns the dial (to less to hear its effect).
(12:10) P24 uses the loop-shift buttons to dynamically move a 4-note selection across the grid.
(12:40) After resetting the loop length to 8, P24 creates a 'bass drum-like' pattern by shifting the pitch into the lowest range and setting every second note in the bottom row.

Leaving: After a short conversation with P25, both leave.

Facilitation: No
Co-participation: Yes (mainly P24 editing)

Instance: 14 (13:30 - 18:00)
Sound set: I
Instrument 2

Participant(s) description: Young woman (20-25) (P26), accompanied by her boyfriend (25-30) (P27).

Approaching: P25 and P26 arrive at the installation whilst only instrument 3 is in use. After taking a short look at instrument 2 together, P26 stays at instrument 2 (note grid wiped, loop length 8), P27 takes over instrument 1.

Playing techniques and interaction:

- (13:38) P26 sets a single note on the first beat of the loop and lets it play for several times
(13:50) P26 creates a closed musical figure (diagonal upwards) and follows its playback with her finger.
(14:05) Letting the figure play, P26 presses the 'slow' button for several times (no effect as the tempo is already set to slow) and then moves the dial for a little amount into both directions (to less to hear it affect).
(14:35) P26 looks up and makes a comment to P27 at instrument 1.
(14:40) P26 extends the loop length to 8, and after a few edits, resets it to a length of 2 beats.
(15:25) P26 creates a 4-note pattern and creates variations by changing the active selection via the loop length buttons to play back different parts of the pattern.
(16:30) P26 continuous editing by creating mainly 'sparse' musical patterns (loop length 6 and 8). After each pattern created, P26 resets the grid before creating a new one.
(17:30) For the second time, P26 moves the dial for a little amount into both directions (to less to hear it affect). She leans over to P27 at instrument 1, points at the Sound Dial and asks him (in German) "Have you already found out what this is for?".
(17:40) In response, P27 turns the dial of his instrument alternately to its positive and negative end position (it is not clear if he is actually aware of the effect or not).
(17:45) [The interface of P26's instrument is obscured by a by-stander.]
(18:00) P26 wipes all notes and leaves the instrument.

Leaving: -

Facilitation: No

Co-participation: No (splitting up to individual instruments)

Instance: 15 (15:40 - 22:00)

Sound set: 1

Instrument 3/2

Participant(s) description: Man (30-35) (P28), accompanied by girlfriend (25-30) (P29).

Approaching: P28 and P29 arrive at the installation whilst all instruments are taken and join the group of spectators surrounding the table. When instrument 3 becomes available, P28 walks towards it and takes it over (previous pattern still running, loop length 8). P29 remains in her 'spectator position' between instruments 3 and 2 around 1 metre away from the table observing the players.

Playing techniques and interaction:

- (15:55) At first, P28 wipes all the notes. He creates several closed musical figures (e.g. diagonal downwards/upwards) and varies them into more open musical figures.
(16:20) Letting an open figure play, P28 tries out several function buttons (e.g. loop shift, pitch shift). M also touches the dial but does not seem to reveal its purpose.
(16:40) P28 reorganises all notes into a straight line pattern and varies it by either deleting or altering single notes of the 'line'.
(17:15) P29 turns towards him and says something. P28 starts to explain the interface. While talking to P29, P28 follows the current pattern with his finger according to the loop based playback before reorganising all notes into a straight line pattern.
(17:30) P28 steps a bit aside and P29 takes over the instrument. P28 obstructs the view standing between table and camera. But it appears P28 continues giving advice while P29 is editing.
(17:55) P28 moves around P29 to the other side of the instrument and points out the function buttons to her.
(18:05) When instrument 2 becomes available, P28 takes over the free instrument whilst P29 remains at instrument 3.
(18:30) After discussing across the table, P28 and P29 switch instruments: P28 returns to instrument 3 and P29 takes over instrument 2.
(18:35) P28 leans over to P29 and shows her how to change the loop length via the buttons in the top row.
[Both continue editing for several minutes, each mainly focused on his/her instrument.]

Leaving: When P29 steps away from the instrument, she is approached by the research assistant with the request to fill in a questionnaire (20:50). P28 continues playing for a bit before he turns to the research assistant (21:40) to fill in a questionnaire as well.

Facilitation: No

Co-participation: Yes (co-participation at first, then splitting up to individual instruments)

Instance: 16 (25:15 - 26:20)

Sound set: 1

Instrument 2

Participant(s) description: Young women (20-25) (P30), accompanied by boyfriend (25-30) (P31).

Approaching: P30 and P31 arrive at the installation whilst all instruments are taken. They closely approach Polymetros and remain standing between instrument 1 and 2. They jointly observe the player at instrument 2 while discussing, and P31 appears to explain the loop-based concept supported by rhythmical hand gestures indicating the sequenced playback. When the player leaves (25:30) P30 and P31 take over the instrument (previous pattern still running, loop length 8).

Playing techniques and interaction:

- (25:30) P31 delete all notes on the grid. P30 creates a closed musical figure (downwards diagonal) and resets the grid again.
(25:50) P30 sets the tempo to 'fast' and creates a straight line of notes. In turn, P31 and P30 vary the pattern by altering single notes.
(26:05) P30 turns the dial slightly left and right, but appears not to recognise its effect.
(26:10) P31 applies several function buttons (pitch shift, loop shift), while P30 continues editing the note pattern.

Leaving: While P30 is still editing, P31 takes a step back and turns away from the installation. P30 deletes all the notes from the grid and follows P31.

Facilitation: No

Co-participation: Yes (joint editing)

Instance: 17 (26:10 - 27:40)

Sound set: 1

Instrument 3

Participant(s) description: Young man (20-25) (P32).

Approaching: P32 arrives at Polymetros whilst only instrument 2 is in use. P32 pauses for a moment observing the interface of instrument 3 (previous pattern still running, loop length 4), then he starts editing.

Playing techniques and interaction:

- (26:25) P32 starts altering single notes of the set pattern.
(26:30) P32 turns the dial to its positive end position (sound gets brighter/more resonant) and holds it.
(26:40) Holding the dial with one hand, P32 continues editing notes and loop length with the other.
(27:10) Letting the same pattern play, P32 uses several function buttons. In turn, P32 applies a number of pitch shifts and moves the selection across the grid using the loop shift buttons. He then turns the dial back and forth between neutral and positive end position.
(27:40) P32 picks up a flyer from the tabletop and leaves the installation.

Leaving: -
Facilitation: No
Co-participation: No

Instance: 18 (27:00 - 34:00)

Sound set: I
Instrument 1

Participant(s) description: Young man (20-25) (P33).

Approaching: P33 arrives at the installation with a companion whilst all instruments are taken and a group of spectators is surrounding the table. While his companion leaves, P33 joins the spectators and positions himself near the table between instrument 1 and 2. P33 closely observes the active players. P33 makes a comment to the player on instruments 1 (31:00) who leaves short after, and P33 takes over the instrument (previous pattern still running, loop length 8).

Playing techniques and interaction:

- (31:15) P33 changes the loop length to 4 and reorganises the notes into a straight line and sets the tempo to fast. [instrument 1 occluded by spectator for brief period]
(32:00) P33 creates another straight line figure and successively transposes the 'line' until he reaches the lowest row of the grid and continues this interaction strategy by starting again from the highest row.
(32:40) P33 starts altering the straight line figure and creates various closed musical figures (diagonal upwards, diagonal downwards and combinations of both).
(33:10) P33 is approached by a woman he apparently does not know who ask him: "How to play this?". While talking to her, P33 emphasises the playback of the pattern with his finger. Then P33 demonstrates how to change the loop length and appears to explain that the pitch is organised from high to low by setting and pointing out a note in the highest row, then in the lowest row. The woman points at the other instruments and asks: "And they playing together?" (33:40). P33: "Yes" (nodding). P33 creates a straight line figure and follows the playback with his finger. The woman 'picks up' his gesture and rhythmically 'points out' the pattern in the air. P33 transposes the figure for several times, than he makes an inviting gesture towards her and hands over the instrument.

Leaving: After having explained the instrument to a woman who approached him, P33 hands over the instrument and leaves.

Facilitation: -
Co-participation: Yes (explanation to an unknown audience member)

Instance: 19 (33:00 - 38:00)

Sound set: I
Instrument 1

Participant(s) description: Woman (30-35) (P34).

Approaching: P34 arrives at the installation whilst all interments are taken. When two spectators leave, she 'fills their gap' close at the table. P34 approaches the player at instrument 1 (P33) and asks him how to play. P34 explains the instrument to her as described in instance 18 (33:00).

Playing techniques and interaction:

- (34:10) P34 starts editing the pattern of the previous player and creates a number of closed musical figures.
(34:35) P34 reorganises all notes into straight line figure. She then starts altering single notes of the sequence letting each new variation play for at least one playback cycle.
(35:00) P34 turns towards the assistant standing at the rear of the booth and comments: "That's cool." and performs some dance moves which she keeps up doing occasionally throughout the rest of her playing instance.
(35:25) Letting the same pattern play, P34 dynamically changes the pitch range after each repetition.
(35:55) P34 repeats this interaction pattern by dynamically changing the tempo between fast and slow.
(36:30) P34 resumes editing the note pattern and creates variations of mainly closed musical figures and reapplies dynamic changes of tempo and pitch range.
(37:40) P34 turns to a young man who arrived "Do you wanna try?" P34 makes a step aside for the man to move in front of the instrument. P34 demonstrates how to change the loop length and reorganises all notes into a straight line. While talking, P34 illustrates the loop-based playback with rhythmical hand movements. P34 demonstrates the pitch shift function and alters a single note in the 'line' before she hands over the instrument to him. P34 takes a step back and is approached by the assistant with the request to fill in a questionnaire.

Leaving: Before P34 leaves, she approaches and explains the instrument to a by-stander.

Facilitation: -
Co-participation: Yes (explanation to an unknown audience member)

Instance: 20 (43:25 - 1:12:00)

Sound set: I
Instrument 1,2,3

Participant(s) description: Three man (25-30) (P35, P36, P37).

Approaching: P35 and P36 arrive at the installation whilst only instrument 3 is in use. P35 determinedly walks up to instrument 1 (note grid wiped, loop length 8). P36 stops at ~1m distance from the table and observes the players.

Playing techniques and interaction:

- (43:30) P35 creates some 'sparse' two and three note patterns and tries out dial and pitch shift function.
(44:00) P35 sets the loop length to 1 and holds the Sound Dial in its positive end position resulting in a resonant single note pattern reminiscent of an 8th-note bass figure.

(44:20) P35 starts rhythmically varying the single note pattern by dynamically changing the pitch in time with the overall pulse accompanied by rhythmical head nodding.

(44:35) P36 walks around the table and joins P35. P36 stands next to P35 and watches him playing.

(44:45) P35 continues his dynamic play on a single active 'column'.

(45:15) P35 and P36 are joined by P37. P36 and P37 chat and watch P35 playing.

(45:40) P35 continues editing by creating mainly short phrases that he changes dynamically.

(46:15) P35 takes a step aside and hands over the instrument to P37. P35 is approached by the research assistant with the request to fill in a questionnaire. P35 agrees and starts filling it in on the table next to P36 and P37 who started co-editing on instrument 1 (P37 edits notes, P36 controls the Sound Dial).

(48:30) When P35 has finished filling in the questionnaire, he rejoins P36 and P37 and they play together at instrument 1 while chatting to each other [interface obscured by P35].

(49:55) Instrument 2 and 3 become available and the group splits up: P37 remains at instrument 1, P36 takes over instrument 2, and P35 instrument 3. They continue playing on individual instruments for several minutes, occasionally chatting with each other across the table. All three make frequent use of the Sound Dial, often keep holding it in its positive end position while editing with the other hand.

(52:20) P36 deletes all notes on the grid, addresses P35 and P37, and in turn points at their instruments. It appears P36 is identifying which pattern and sound comes from which of his friends' instruments.

(53:40) P36 takes a step aside from his instrument which is immediately taken over by waiting spectators. P36 joins P35 at instrument 1. When P37 indicates he might leave his instrument as well, he is approached by the research assistant with the request to fill in a questionnaire which he agrees to do.

P35 continues playing at instrument 3 making extensive use of the dial, loop and pitch shift functions. P35 creates mainly short patterns (2,3, and 4 beats) which he edits dynamically by changing notes and using the function buttons while his right hand remains controlling the Sound Dial.

(56:30) Having finished the questionnaire, P37 rejoins P35 and P36 at instrument 3 (only P35 editing) before he leaves the booth (58:00). P35 continues playing at instrument 3 accompanied by P36.

(1:01:00) P37 returns to the installations and takes over instrument 2 which just became available.

(1:01:15) P36 stands between instrument 3 (P35) and instrument 2 (P37) alternately chatting to both of them, apparently in relation to the Sound Dial.

(1:01:30) P36 asks P35 to turn and hold the dial at its negative end position. P36 leans across the table and turns the dial of instrument 1 (played by a visitor who does not belong to the group) in its negative end position, holding it for a moment.

(1:02:15) P36 leaves the installation, P35 and P37 continue playing occasionally chatting across the table.

(1:03:55) P35 reaches over to P37's instrument and turns the dial in its negative end position (as does he). P37 then turns the dial alternately to its positive, negative, and neutral position apparently comparing the different effects on the sound.

(1:04:37) P37 leaves instrument 2. (Potential reason: A TV camera team starts preparing and filming for an interview in front of instrument 2). P37 joins P35 for a moment, then leaves the booth.

(1:05:35) P36 returns to the booth and takes over instrument 1.

(1:06:05) P37 returns to the booth and after the interview is finished, he takes over instrument 2 again (all group members on individual instruments again.)

(1:09:35) P36 is approached by a girl and steps away from instrument 2 which is immediately taken over by two observing by-standers. P36 and the girl stay in vicinity of P35 (instrument 3).

(1:10:15) P37 offers his instrument (1) to a by-stander with an inviting gesture. The by-stander takes over the instrument and P37 joins P35 at instrument 3.

Leaving: Shortly after P37 and the girl have left the installation, P35 and P37 leave too.

Facilitation: No

Co-participation: Yes (co-participation at first, then splitting up to individual instruments)

Sound Set II (Electronica/Techno)

File: M2U00047.MPG

Date: 14.06.2013

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Instance: 21 (5:00 - 6:40)

Sound set: II

Instrument 1 (Drum machine)

Participant(s) description: Two men (30-35) (P38, P39).

Approaching: P38 and P39 arrive at Polymetros right after the day's change of sound sets and are the first to start playing. They approach instrument 1 with the base drum set on every second beat (loop length 4).

Playing techniques and interaction:

(5:10) P38 starts editing by setting and resetting several notes in different drum rows.

(5:15) P38 points with his finger along the button/row labels at the right side, apparently studying their purpose. P38 tries out the tempo buttons and switches several time between slow and fast.

(5:30) P38 sets the loop length to 8 and after setting and resetting several notes P38 wipes all notes except the bass drum figure. P39 stands next to P38 watching him play.

(5:40) P38 extends the bass drum pattern (drum on every 2nd beat) to the new loop length. He adds closed hi-hats (2x) and rimshot (1x) and lets the pattern play for several times.

(5:55) P38 continues editing by adding and deleting notes in a 'fluent' manner, while repeatedly pausing after several edits to let play the new variation.

(6:25) P39 makes a single loop length edit. P38 immediately takes over and dynamically changes the loop length several times.

(6:40) P39 touches and turns the dial slightly (does not seem to uncover its effect).

Leaving: Two women arrive, one positions herself closely to P38. He turns towards P39, and both leave the installation.

Facilitation: -

Co-participation: Yes (mainly P38 editing)

Instance: 22 (5:30 - 7:30)

Sound set: II

Instrument 2

Participant(s) description: Group of three, two female, one male (25-30) (P40, P41, P42).

Approaching: P40 and P42 arrive at the installation together, P41 joins them later. P40 and P42 take over instrument 2 that becomes available shortly after they arrive (note grid wiped, loop length 5).

Playing techniques and interaction:

(5:45) P40 bends down towards and brings her ear close to the instrument.

(5:50) While chatting to P42, P40 sets a single note on the first beat lets it play for three times, and then deletes it. P42 watches and nods. P41

approaches the installation and joins them.
 (5:55) P42 sets a two-note pattern. After several repeats, P40 deletes the notes and begins to create a new pattern.
 (6:10) P41 and P43 start co-editing and all three contribute and delete notes in turn.
 (6:30) P42 touches and slightly turns the sound dial but does not seem to 'uncover' its function.
 (6:45) The group is approached by a man. P42 turns towards him and takes a step back from the table. Both chat to each other while pointing towards the instruments. P40 and P41 continue co-editing in turn.
 (7:00) P40 deletes all notes and the group leaves the installation together.

Leaving: -
 Facilitation: -
 Co-participation: Yes (joint editing)

Instance: 23 (05:10 - 9:35)
 Sound set: II
 Instrument 3

Participant(s) description: Man (30-35) (P43).

Approaching: After watching the installation and active players from a distance for a short while, P43 walks around the table to take over the remaining, currently free instrument (note grid wiped, loop length 5).

Playing techniques and interaction:

(5:35) P43 starts to create simple two-note figures and successively changes one of the two notes letting each variation play for several playback cycles.
 (6:10) P43 continues with this interaction style but increases the number of notes in the pattern creating mainly combined open and closed figures.
 (6:45) P43 resets all notes. (No input for 15 sec, P43 appears to deliberate 'what to do next')
 (7:00) P43 creates a closed musical figure (diagonal upwards). Letting the figure play, P43 takes hold of the dial and slowly turns to the right (sounds gets brighter/more resonant).
 (7:15) While modifying the sound characteristic with the dial, P43 simultaneously edits the pattern with the other hand, letting each new variation play for at least one playback cycle.
 (7:50) P43 reorganises all notes into a straight line figure. He alters and 'recreates' the line pattern several times applying the dial (mainly alternating between negative and positive end position).
 P43 continues with this interaction style - He repeatedly creates closed figures (e.g. line, diagonal up) which he then varies while turning the sound dial alternately to its end positions.

Leaving: -
 Facilitation: -
 Co-participation: -

Instance: 24 (8:30 -10:00)
 Sound set: II
 Instrument 2

Participant(s) description: Two young man (20-25) (P44, P45).

Approaching: After approaching the table, P44 reaches out from the side and presses a button of instrument 2 in front of which a man is standing reading a leaflet. The man steps aside and P43 positions himself in front of the instrument. P44 stands at his side.

Playing techniques and interaction:

(8:40) At first, P43 deletes the set pattern from previous players and resets the loop length to 4.
 (8:45) P43 creates a closed linear figure (downward diagonal) and makes a comment to P44.
 (8:55) P44 points to the Sound Dial. P43 turns it to its negative end position (sound becomes more percussive) while P44 starts editing the pattern.
 (9:00) P43 resets the loop length to 8 and both jointly edit the pattern.
 (9:25) In turn, they apply different functions (tempo change, pitch shift, loop shift) and discuss their outcome.

Leaving: -
 Facilitation: -
 Co-participation: Yes (joint editing)

File: M200002.MPG
 Date: 15.06.2013
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Instance: 25 (6:40 - 9:45)
 Sound set: II
 Instrument 3

Participant(s) description: Man (25-30) (P45).

Approaching: P45 arrives at the installation and takes over the remaining, currently free instrument (note grid wiped, loop length 5).

Playing techniques and interaction:

(6:45) P45 sets and resets several notes, but he does not have seem to understand the loop-based concept yet ('don't know' gesture, both palms turned up (7:00)).
 (7:10) P45 turns towards instrument 2 where the facilitator explains the installation to an audience member.
 (7:20) P45 focuses on the grid of instrument 2 and then recreates a similar pattern on his instrument (diagonal closed musical figure).
 P45 starts 'bopping along' to the beat with his whole body.
 (7:30) P45 creates several variations of the diagonal figure.
 (7:45) P45 sets some notes outside of the active area (repeats 'don't know' gesture).
 (7:50) P45 creates a closed alternating pattern and slightly turns the dial (to less causing effect).
 (8:00) P45 'discovers' how to extend the loop length, sets it to eight and deletes all notes from the grid.
 (8:20) P45 creates a closed, three-note pattern that he recreates after shifting the active selection to the end of the grid (3 beats long) -> short repetitive motive.
 (8:30) P45 is addressed by a girl he apparently does not know, who is playing at the drum machine instrument (while dancing). She appears to signalise to him that she is 'responsible' for the beat.
 (8:45) P45 continues varying the short pattern, letting each new variation play for several times.

(9:15) P45 sets the loop length to 1 (only one note playing on repeat). It appears he wants to 'switch off' the grid completely.
(9:25) P45 resets the grid to 7 and varies a sparse pattern, letting each variation play for at least one loop cycle.

Leaving: P45 is addressed by a companion (by-stander) on the other side of the table who just finished taking a video recording of P while playing. He apparently urges P45 to move on. P45 leaves the instrument and they move on together.

Facilitation: -
Co-participation: -

Instance: 26 (7:35 -20:20)
Sound set: II
Instrument 2/1 (Drum machine)

Participant(s) description: Two man (25-30) (P46, P47).

Approaching: P46 and P47 arrive at the installation whilst all instruments are in use. Standing at ~1.5m distance from the table they observe the active players and chat to each other. When instrument 2 becomes available they take over the instrument (previous pattern still running, loop length 7).

Playing techniques and interaction:

P47 positions itself in front of the instruments, P46 stands alongside.
(9:10) At first, P47 deletes all notes of the previous players and both start co-editing. While the editing is mainly 'dominated' by P47, P46 contributes several additional edits.
(10:00) P46 recognises that instrument 1 (Drum machine) became available, leaves P47 at instrument 2, and takes over instrument 1.
(10:10) At first, P47 resets all notes of the previous player. Then he repeatedly sets and resets a single note.
(10:15) P46 says something to P47 at instrument 2 and bends down close to the instrument for better audibility (stationary, extremely high background noise). Also P47 leans over the table to be able to 'spot' instrument 1.
(10:25) P46 resets the grid and creates a 4/4 bass drum pattern (kick on every second beat, tempo fast).
(10:35) After setting and deleting a single snare at different positions, P46 counts along the bass drum pattern indicated by his pointing finger to find the 'right position' where to put the snare in the pattern. After several playback cycles P46 places a snare drum on the last kick drum of the pattern.
(10:45) P47 (instrument 2) again leans over the table to better determine the drum instruments' output.
(10:50) P46 adds a regular closed hi-hat pattern (on downbeat with kick), and open hi-hats on the 'off-beats'. In combination, kick, snare and hi-hats form a typical basic techo/house drum pattern.
P46 varies the drum pattern several times (e.g. deletes hi-hats, adds rim shots) but maintains the typical 4/4 dance music structure.
(11:55) P46 presses several times the lowest function button (mute kick) very shortly (no effect). Standing next to him, the facilitator shows him that mute function is only active as long the button is pressed.
(12:30) P46 starts using the Sound Dial. Due to extremely loud background noise (dance music played from a nearby booth via PA system), P46 leans forward and brings his ear closely to the embedded speaker, apparently to 'spot' the effect of the dial.
(12:50) P46 turns the dial quickly between its negative and positive end positions.
(13:00) P47, who changed from instrument 2 to instrument 3 (11:30), leans over the table with his ear directed towards instrument 1 (Drum machine).
(13:10) P46 leaves instrument 1 and joins P47 at instrument 3. Instrument 1 is immediately taken over by a by-stander.
(13:30) P46 is approached by the research assistant agrees to fill in a questionnaire. As does P47 a little later.
(19:00) After both have finished the questionnaires, P46 takes over instrument 1 and P47 instrument 2 and they continue playing.
(20:00) P46 takes out his mobile phone and asks a by-stander at the other side of the table to take a picture of him and his friend (P47) playing on different instruments. After he receives his phone back, he steps away from the instrument which is immediately taken over by another audience member.
(20:20) P46 approaches P47 at instrument 2, shows him the picture, and both leave the installation.

Leaving: -
Facilitation: Yes (explanation of mute function)
Co-participation: Yes (co-participation at first, then splitting up to individual instruments)

Instance: 27 (19:20 - 21:25)
Sound set: II
Instrument 1 (Drum machine)

Participant(s) description: Young woman (20-25) P(48), accompanied by man (25-30) P(49).

Approaching: P48 and P49 arrive at the installation whilst all instruments are in use. They remain standing in ~2m distance from the table. Drinking beer and chatting to each other, they occasionally 'glance' at the installation. When instrument 1 becomes available, they take over the instrument (previous pattern still running: 4/4 kick and hi-hat pattern, loop length 8).

Playing techniques and interaction:

(20:20) P49 tries out the Sound Dial. P48 points towards instrument 2 to make P49 aware that it became available as well -> P49 takes over instrument 2, P48 remains at instrument 1.
(20:40) P48 adds several notes, slightly turns the dial, and shortly presses several mute buttons (no effect). In general, it appears that P48 did not understand the loop-based concept of the interface.
P48 tries several functions 'randomly' and uses several fingers at once for inputting notes. As a result, the grid becomes 'cluttered' with notes.

Leaving: After a comment from a companion who just joined in on instrument 3 which P48 appears to reply peevishly, she leaves the instrument and joins P49 at instrument 2.

Facilitation: -
Co-participation: Yes (co-participation at first, then splitting up to individual instruments)

File: M200003.MPG
Date: 15.06.2013
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Instance: 28 (3:05 - 9:00)
Sound set: II
Instrument 1 (Drum machine)

Participant(s) description: Two men (P50, P51).

Approaching: P50 arrives at the installation whilst all instruments are in use and the table is 'densely' surrounded by on-lookers. P50 and P51 wait in 'second row' (faces not visible). When there is a 'gap' between spectators, P50 steps forward, picks up and reads a 'Polymetros' flyer from the tabletop, and then starts closely watching the active players. When instrument 1 becomes available P50 takes over the instrument (4:40) (previous

pattern still running, loop length 8). [P2 left the booth].

Playing techniques and interaction:

- (5:00) After a few note edits, P50 deletes all rows except for the highest (tom), in which all notes are selected.
(5:20) P50 adds a few notes, tries out the mute buttons (presses shortly -> no effect) and changes the loop length letting the pattern play for several times between each change.
(5:40) P50 turns the dial slowly to its left end position (LP filter effect) and holds it for a moment (drums are entirely 'filtered' out). Then he releases the dial to 'bring the beat back' instantly. P50 'augments' this action with a dramatic 'retraction' gesture of his whole arm. P50 smiles and starts nodding his head to the beat.
(5:50) P50 addresses P51, who took over instrument 2 (5:15) after returning to the booth, apparently to show him this effect. P51 looks up for a moment, but quickly focuses back on his instrument.
(6:15) P50 repeats this 'filter effect' (and associated gesture) for several times while editing the pattern.
[instrument occluded by assistant]
(6:40) P50 is joined by P51 who left instrument 2. As it appears (instrument still partly occluded by assistant), P50 shows P51 the 'filter effect' he performed before. While they discuss with each other, P51 uses the dial following P50's instructions.
(7:15) P2 shows P1 how to change the loop length, P1 nods.
(7:30) They continue discussing. P51 points to the other instruments before leaning forward to closely listen to the drum instrument.
(7:40) P50 creates a typical dance pattern (4/4 kick, alternating with snare) and dynamically edits the loop length.
P50 and P51 continue by jointly editing notes and functions while commenting/discussing their actions.

Leaving: -

Facilitation: -

Co-participation: Yes (Individual instruments at first, then co-participation at one instrument)

Instance: 29 (21:45 - 23:10)

Sound set: II

Instrument 1 (Drum machine)

Participant(s) description: Two men (30-35) (P52, P53).

Approaching: They approach the installation whilst none of the instruments is in use, all note grids are wiped. P52 holds a drink in his left hand.

Playing techniques and interaction:

- (21:50) Before making any input, P53 starts explaining the concept to P52 by indicating the direction of playback and the different rows. Then, P53 sets three notes and highlights them with his finger when played.
(22:00) With his free hand, P52 follows the playback of the pattern with his finger for several times before adding single notes to the pattern, letting each new variation play for at least one time.
(22:15) P52 starts dancing in front of the instrument.
(22:40) P52 continues adding single notes, while dancing and chatting with P1 -> the grid becomes more and more 'cluttered'.
(22:50) P53 appears to give some 'playing advice' while pointing at the grid. P52 shakes with laughter.

23:00 P52 takes a step back from the instrument indicating an attempt to leave. P53 starts deleting all notes before they leave.

Leaving:

Facilitation: -

Co-participation: Yes (joint editing)

File: M200004.MPG

Date: 15.06.2013

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Instance: 30 (0:35 - 3:30)

Sound set: II

Instrument 1 (Drum machine)

Participant(s) description: Young man (25-30) (P54).

Approaching: After having played at instrument 2 for around 3 min (interface obscured for most of the time), P54 changes to instrument 1 (note grid wiped, loop length 8).

Playing techniques and interaction:

- (0:45) P54 sets several notes across the grid.
(0:50) P54 repeatedly presses different mute buttons (presses shortly -> no effect).
(1:10) P54 turns the dial to its positive and negative end position.
(1:20) P54 adds more notes and presses mute buttons in quick succession (no effect).
(1:30) P54 activates all notes (different drums) in one single column and turns the dial to its positive end position -> leads to distinct 'prolonged' decay effect.
(1:40) P54 adds further notes and repeats using the dial in the same manner.
(1:55) P54 deletes all notes from the grid.
(2:00) P54 sets two notes (rimshots) and lets the figure play for several times while turning the dial to its positive end position.
(2:15) P54 successively adds several notes in a 'systematic' manner (first hi-hats, then kick).
(2:30) P54 is approached by a young woman, they have a quick chat, she leaves and P54 focuses back on the instruments.
(2:50) P54 adds more notes to the pattern and uses the dial repeatedly in the same manner than before.
(3:00) P54 continues editing by alternately deleting and adding entire parts of the pattern.
(3:30) P54 takes a step back from the instrument and picks up and reads the Polymetros flyer.
(3:45) When instrument 3 becomes available, P54 continues playing at instrument 3 and later changes to instrument 2 (7:00-8:10).

Leaving: -

Facilitation: -

Co-participation: -

Instance: 31 (10:40 - 14:10)

Sound set: II

Instrument 2

Participant(s) description: Young woman (20-25) (P55), joined by man later (25-30) (P56).

Approaching: P55 arrives at the installation whilst all instruments are in use. P55 stops at some distance from the table (~2m) and takes a picture. P55 takes a step closer and picks up and read a 'Polymetros' flyer from the tabletop before she starts closely watching the active players. When the players at instrument 2 leave, P55 takes over the instrument (previous pattern still running, loop length 8).

Playing techniques and interaction:

- (12:20) At first, P55 deletes the set pattern note by note, one note per playback cycle.
- (12:40) P55 creates a three-note, closed musical figure (diagonal upwards), lets it play for several times, and then adds more notes to the 'diagonal'.
- (12:50) P55 is approached by P56.
- (13:00) P55 addresses him, deletes all notes and starts to create a new pattern (most likely meant as demonstration for P56). Then P55 continues to vary the pattern by altering single notes and chanting the loop length.
- (13:25) P56 slightly turns the dial in both directions (to less to cause effect).

Leaving: While P55 continues playing in a similar manner, P56 leaves and positions himself a few meters away from the installation. After half a minute, P55 deletes all notes, joins P56, and they leave together.

Facilitation: -

Co-participation: Yes (mainly P55 editing)

File: M200005.MPG

Date: 15.06.2013

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Instance: 32 (11:00 - 13:50)

Sound set: II

Instrument 2

Participant(s) description: Man (30-35) (P57), accompanied by a group of four friends.

Approaching: P57 approaches the installation and instantaneously takes over instrument 2 (note grid wiped, loop length 5). P57 is followed by four friends who arrive one after another and group themselves around him.

Playing techniques and interaction:

- (11:10) P57 starts by creating a straight line of notes and turns the dial.
- (11:15) One of his friends who just arrived 'interferes' by adding notes and pressing function buttons in quick succession. Another friend sets the loop length to 8.
- (11:30) P57 takes over control again and deletes all notes from the grid.
- (11:40) Holding the Sound Dial in its positive end position, P57 creates a simple pattern (successive notes on two different pitches) and starts 'bopping along' to the beat with his whole body.
- (11:45) P57 turns the dial quickly several times and then holds it in its negative end position (sound gets shorter/more percussive).
- (12:00) P57 continues by dynamically changing the loop length to create variations of the pattern while alternately turning and holding the dial in its end positions.
- (12:30) [In the meantime, two of his friends have taken over instrument 3 (interface mostly obscured by one of them)]
P57 continues playing in a similar manner adopting a dynamic 'performative' posture 'bent over' the instrument while performing exaggerated hand gestures when e.g. pressing a button or releasing the dial.
- (12:40) [P57's instrument's interface partly occluded by spectator]
- (13:00) P57 appears to demonstrate the dial's effect to one of his friends.
- (13:15) P57 creates a closed straight line and starts to dynamically deleting and resetting it on a different pitch by sliding his finger over the entire row in one go.
- (13:35) P57 switches the pitch dynamically between different octave ranges.

Leaving: P57 joins two of his friends who appear to 'wait for him', having already taken a step back from the installation.

Facilitation: -

Co-participation: Yes (joint editing in the beginning)

File: M200006.MPG

Date: 15.06.2013

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Instance: 33 (3:00 - 5:00)

Sound set: II

Instrument 3

Participant(s) description: Two women (30-35) (P58, P59).

Approaching: P58 approaches the installation just at the moment when the player on instrument 3 is leaving and promptly takes over the instrument (note grid wiped, loop length 8).

Playing techniques and interaction:

- (3:15) P58 sets several notes on the grid
- (3:20) P58 is approached by P59 who joins her at the instruments.
- (3:30) P58 adds notes and presses some function buttons but appears to not have understood the interface concept ('Don't know' gesture, both palms turned up).
- (3:35) P59 deletes all notes from the grid.
- (3:40) P58 sets a single note and tries out the button row on top to change the loop length.
- (3:45) P58 seems to 'grasp' the loop-based concept repeatedly pointing along with the 'light bar' travelling across the grid. P59 turns the dial slightly and presses it like a button.
- (3:50) P58 creates a two-note figure and points to the notes when they are played. She adds more notes and P59 who nods.
- (4:10) They continue by trying and discussing several functions together (tempo and pitch change, loop shift).
- (4:25) P58 sets the loop length to 8 and both create and vary an eight-note pattern. P58 is repeatedly pointing along the pattern.
- (4:40) Letting the same pattern play, P58 appears to demonstrate the pitch shift function to P59 by switching several times back and forth between two octave ranges while addressing P58 (nodding).

Leaving: -
Facilitation: -
Co-participation: Yes (joint editing)

Instance: 34 (25:50 - 27:50)
Sound set: II
Instrument 2

Participant(s) description: Two man (30-35) (P60, P61).

Approaching: P60 arrives at the installation alone and takes over instrument 2 that just became available (previous pattern still running, loop length 5).

Playing techniques and interaction:

(25:50) P60 presses several buttons on the grid and turns the dial slightly.
(26:00) P60 is approached by P61. P61 was playing on instrument 2 earlier (24:20-25:05), but stepped back when a group of three 'interfered' by starting to edit the grid alongside him.
P60 immediately 'takes over' editing and creates a closed musical figure (diagonal down) and points along the played notes.
(26:20) P61 varies the closed musical figure several times (e.g. up/down) while pointing along.
(26:25) P60 creates a straight line of notes and P61 appears to highlight the playing direction with his hand.
[instrument occluded by spectator]
(26:40) P60 creates a step-like pattern and points at the played notes while addressing P61.
Both start to co-edit the pattern in turn.
(27:15) P61 leaves the instrument.
(27:20) P60 'discovers' the loop length button in the top row and repeatedly varies the active playback section. After changing the tempo back and forth for several times, P60 'tracks' the pattern with his finger at the 'newly' set tempo.

Leaving: -
Facilitation: -
Co-participation: Yes (joint editing)

Instance: 35 (28:00 - M200007.MPG(*):0:15)
Sound set: II
Instrument 1 (Drum machine)

Participant(s) description: Young man and woman (20-25) (P62, P63), joined by friend (male, same age) later (P64).

Approaching: P62 arrives at instrument 1 where P63 has activated all notes on the grid before (entire active section 'red', all drums play at once, loop length 4). P63 does not seem to have understood the instrument's functionality.

Playing techniques and interaction:

(28:30) P62 tries to 'work it out' by deleting parts of the 'cluttered' grid and then adding single notes.
(28:40) With a questioning expression P62 addresses the facilitator (F) who is standing nearby. F points out the basic concept by creating a simple drum pattern (4/4 kick, snare + hi-hats). P62 (nodding): "Ah ok, Thank you."
(29:00) P62 starts to add notes to the pattern, while P64 (who approached during the explanation of the facilitator) changes the loop length several times.
(29:25) P62 delete all notes except the 4/4 kick drum.
(*0:05) P62 appears to explain P64 the concept of the different 'drum rows' (points them out on the interface, while P64 inputs 'clusters' of notes which his whole hand.
(*0:15) P62 leaves the instrument, P64 takes over.

Leaving: -
Facilitation: -
Co-participation: Yes (joint editing)

File: M200007.MPG
Date: 15.06.2013
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Instance: 36 (0:25-1:45)
Sound set: II
Instrument 2

Participant(s) description: Couple (25-30) (P65 [m], P66 [f]), approached by man (30-35) later (P67).

Approaching: P65 and P66 arrive at the installation whilst all instruments are in use. Standing at some distance (~1,5m), they observe the active players.
When instrument 2 becomes available, they take over the instrument (previous pattern still playing, loop length 7).

Playing techniques and interaction:

(0:25) P65 makes several note edits, holds the dial and changes the loop length.
(0:50) P67, who approached the table after them (0:30) (not apparent if they know him or not), addresses them to explain 'how it works'.
(1:00) P67 deletes all notes first and sets a single note.
(1:10) P65 takes over control again, adds several notes and 'discovers' the pitch shift function.
(1:20) P65 reaches for the dial and turns it once while appearing to encourage P65 to use it.
(1:30) P65 slowly turns it to its negative end position and holds it for a moment, then turns it all the way to the right. P65 also tries to push it like a button.

Leaving: While P65 is still editing, P66 picks up her drink from the floor and turns away from the installation. P65 stops playing and they leave together.

Facilitation: -
Co-participation: Yes

Instance: 37 (4:15 - 6:00)
Sound set: II
Instrument 1 (Drum machine)

Participant(s) description: Couple (30-35) (P68 [m], P69 [f]).

Approaching: They arrive at instrument 1 when the previous players are just about to leave (pattern still running, loop length 8)

Playing techniques and interaction:

- (4:20) At first, P68 and P69 jointly delete all notes on the grid.
- (4:30) P68 creates a diagonal figure (maybe seen on an other instrument before?).
- (4:40) P68 deletes all notes except for one and lets it play for several times.
- (4:50) In turn, P68 and P69 create a pattern each and reset the grid afterwards respectively.
- (5:00) Letting a pattern play unaltered for several loop cycles, P68 points at the current playing position with his finger. P69 appears trying to 'push' the Sound Dial like a button.
- (5:15) P68 sets all notes in the 'tom' row, while P69 deletes all other notes.
- (5:30) After wiping all notes, P68 and P69 create three 'columns' (activating all notes in a particular column) and start to jointly vary the pattern.
- (5:50) While P69 resets all notes, P68 is turning the Sound Dial in both directions.

Leaving: While P68 starts creating a new pattern, P69 turns around and steps away from the instrument. P69 'briskly' finishes the pattern and follows P68.

Facilitation: -

Co-participation: Yes (joint editing)

Instance: 38 (4:30 - 7:50)

Sound set: II

Instrument 1 (Drum machine)

Participant(s) description: Young man (20-25) (P70).

Approaching: P70 arrives at the installation accompanied by two friend whilst all instruments are in use. When instrument 3 becomes available, one of his friends starts playing and P70 takes a photo/video of his friend playing and dancing. Then P70 takes over instrument 1 (6:15) which became available (previous pattern still running, loop length 8).

Playing techniques and interaction:

- (6:25) At first, P70 deletes all set notes.
- P70 sets single notes and tries out different functions (loop length, dial) but does not seem to have understood the instrument yet.
- (7:00) P70 is approached by the facilitator who explains instrument by creating a basic drum pattern (instrument partly obscured by facilitator).
- (7:20) P70 adds to and varies the set pattern.
- (7:40) Letting the recent variation play, P70 frolicsomenly dances in front of the instrument while shaking with laughter.

Leaving: P70 is addressed by a companion standing next to one of his friends who plays on instrument 2. P70 offers him the instrument and steps back and the companion takes over the instruments.

Facilitation: Yes

Co-participation: -

Instance: 39 (4:30 - 9:25)

Sound set: II

Instrument 3

Participant(s) description: Young man (20-25) (P71), joined by two friends.

Approaching: P71 arrives with a friend at the installation whilst all instruments are in use. They stand at some distance (~1.5m) from the table and observing the active players while chatting to each other. They are joined by another friend (4:55). When the player on instrument 3 leaves, P71 takes over the instrument (previous pattern still running, loop length 8).

Playing techniques and interaction:

- (5:10) Before P71 starts playing, he poses towards his friends rolling his shoulders and exaggeratedly cracking his knuckles to 'make himself ready to play'.
- (5:20) P71 creates a 'sparse' pattern and starts dancing in front of the instrument.
- One of his friends starts filming him.
- (5:40) P71 crouches down and accompanies the following dial changes with whole body movements (up and down).
- (6:00) P71 strikes a 'DJ-like' pose towards his friend (filming) waving one hand in the air while holding the dial in its positive end position (sound gets brighter, more resonant).
- P71 continues dancing in front of the instrument occasionally changing the pattern or using the dial. His friends take over the two other instruments which became available.
- P71 remains playing in a similar manner, creating mainly simple pattern and extensively using the dial accompanied by whole body movements.
- (7:15) P71 orients himself towards instrument 1 where the facilitator explains the drum machine to his friend (instance 38).
- (7:45) P71 focuses back on his instruments and continues playing in a similar way than before, editing the pattern with one hand while keeping hold of and using the Sound Dial with the other.
- (8:50) P71 addresses an observer standing close to him, a young woman who arrived a while ago (7:30), and offers her to explain the instrument (they apparently do not know each other).
- (9:10) P71 deletes all notes from the grid. P71 demonstrates the instrument by setting a single note and successively building up a simple pattern.
- (9:25) The woman nods, P71 takes a step back and she takes over the instrument.

Leaving: Handing over to bystander after explanation.

Facilitation: -

Co-participation: Yes (explanation to bystander)

Instance: 40 (7:00 - 10:50)

Sound set: II

Instrument 1 (Drum machine)

Participant(s) description: Young man (20-25) (P72), accompanied by friend (previous player (P70), instance 38), explanation to young woman (20-25) later (P73).

Approaching: P72 arrives at the installation whilst all instruments are taken. Being apparently acquainted with the player at instrument 2, P72 stands next to

him and watches him closely. P72 addresses P70 at instrument 1 (instance 38) (he seems to know as well) who offers him his instrument (7:45). P72 takes over instrument 1, P70 takes a step back (previous pattern still running, loop length 8).

Playing techniques and interaction:

- (7:55) After pressing several buttons (notes, mute) rather 'unsystematically' and slightly turning the dial, P70 'intervenes' and deletes all notes.
- (8:05) P70 appears to explain the instrument to P72 and creates a 4/4 bass drum pattern.
- (8:15) They seem to discuss the loop-based concept (indicated by hand gestures) and P70 points out the different rows.
- (8:20) P72 creates a 4/4 HiHat pattern and adds the snare (alternately with kick) -> both start 'grooving' with the beat.
- (8:40) P72 discovers the tempo function and switches several times between slow and fast.
- (8:55) P72 reduces stepwise the loop length to 4, then sets it back to 8.
- (9:15) P72 edits the kick pattern and adds a rimshot figure.
- (9:25) P72 turns to a by-stander who stands next to him, a young woman (P73) he apparently does not know. P72 addresses her and offers to explain her the instrument and P73 steps closer to the instrument.
- (9:30) P72 deletes all notes and indicates the loop based concept with his hand ('chopping gesture').
- (9:40) P72 creates a 4/4 bass drum pattern, demonstrate how to change the loop length and adds a snare pattern alternately with kick.
[interface partly occluded by by-stander]
- (10:15) P72 deletes all notes and appears to explain ('circular' hand gesture across the table) that all sound now comes from the other instruments.
- (10:20) P73 sets all eight notes in the 'tom' row and P72 adds a snare drum on every second beat.
- (10:35) P72 adds a regular hi-hat pattern and points along with its playback.
- (10:40) P73 adds a single rimshot and lets the entire pattern play for several times before she starts deleting 'his' parts.
- (10:50) P72 turns away and joins his group friends that is spread around the booth. P73 continues playing on her own.

Leaving: Handing over to bystander after explanation.

Facilitation: No

Co-participation: Yes (joint editing, explanation)

Appendix D

Choice of *Gamma* for Bivariate Analysis

The following section provides a detailed rationale for the choice of Goodman and Kruskal's (1954) *gamma* as a measure of association for the bivariate analysis of the questionnaire data gathered in this thesis. In particular, it discusses why *gamma* was chosen over Kendall's *tau-b* as a common alternative for ordinal associations, which is advocated by some researcher for being more 'conservative' than *gamma* (Blaikie, 2003, p. 105).

Preselection: At first, a preselection of potential measures of associations was made. The properties of the gathered data, as determined by the questionnaire layout, required a measure of association between two ordinal variables, both with only few categories (5-point scale). According to de Vaus's (2002) guidelines for selecting correlation coefficients for survey analysis, *gamma* and Kendall's *tau-b* are the most appropriate bivariate descriptive statistics in such a case (de Vaus, 2002, p. 293-294).

Correlation Measures: Both, *gamma* and *tau-b* are based on the direct analysis of *concordant* and *discordant* pairs of observations. A pair of observations is concordant if the subject with the larger value on the first variable (x) also has the larger value on the second variable (y). A pair of observations is discordant if the subject with the larger value on the first variable has the lower value on the second variable. Both measures are shown below, where C is the number of concordant pairs and D is number of discordant pairs. T_x and T_y denote the number of *ties* in the first variable (x) or second variable (y), respectively. A tie on one variable occurs if both subjects have the same value.

$$gamma = \frac{C - D}{C + D} \quad (D.1)$$

$$tau-b = \frac{C - D}{\sqrt{(C + D + T_x)(C + D + T_y)}} \quad (D.2)$$

D.1 and D.2 show that the computation of both measures is very similar. The main difference is that *gamma* omits ties, whereas *tau-b* includes them in the denominator. In the case that no ties occur in either variable, *gamma* and *tau-b* are equivalent. If ties occur, *tau-b* becomes smaller as the number of tied pairs increases.

Therefore, the choice of which of both measures to use for the questionnaire analysis, was narrowed down to the question of how to deal with tied observations. In this thesis the view is taken that this decision has to be made on a case by case basis, depending on how occurring ties can be interpreted in the applied case. As the following examples show, the reason for this is that the occurrence of ties and their “construal” (Gonzalez and Nelson, 1996) is dependent on the problem the measure is applied to.

Interpretation of Tied Observations: At the outset, it has to be highlighted that recommendations found in literature on how to handle ties in ordinal associations, in favour for or against the two preselected measures (Costner, 1965; Wilson, 1969; Gonzalez and Nelson, 1996), are related to applications where the measure is aimed to determine the degree of relationship between *two sets of several ranked items* (denoted as rank-ordered lists in the following) - a situation that is notably different from measuring the association between two single questionnaire items, as of interest for this thesis.

An example for measuring the degree of relationship between two rank-ordered lists would be the following: Two persons are asked to rank a list of ten songs according to their liking on a 10-point scale. Respondent A ranks the songs using all ten ranks. Respondent B makes an almost identical ranking with the only exception of assigning the same rank to two songs, favouring both alike. Hence, it is plausible that this affects the association measure as it is meant to describe the degree of relationship between the rank-orders lists. In addition, it is known that the tie was created *intentionally* by the respondent.

Given the case that the number of items to be ranked exceeds the available number of response categories, ties become inevitable and it is not possible to decide if ties were intended or “forced by the procedure”, and therefore are “ambiguous” (Gonzalez and Nelson, 1996). In such a case, Gonzalez and Nelson argue that such ambiguous ties “should be excluded from the denominator because [they] are uninterpretable.”

However, the essential difference to these examples is that the questionnaire analysis aims to determine the degree of relationship between two single items based on the rating of n respondents, not between n items rated by two respondents. As a result, ties occurring on either of both variables are simply caused by the fact that two *different* respondents have used the same response category. Given the sample sizes of the study data ($n = 100-150$) and the small number of available response categories (5-point scale) a large number of ties is inevitable.

Therefore, in analogy with Gonzalez and Nelson’s considerations for associations between rank-ordered lists, the decision to omit ties is based on the fact that all tied pairs are forced by the procedure. In addition, ambiguities as in Gonzalez and Nelson’s example can be excluded as *all* ties occur unintentionally.

Hence, *gamma* was chosen which omits such tied pairs in its calculation, that is, as Freeman (1986) argues, “neither a flaw nor a weakness [but] an unalterable consequence of *gamma*’s association model.”

Practical Implications: According to the way *gamma* and *tau-b* are constructed, it becomes obvious why *tau-b* can be considered more ‘conservative’ (that is smaller) when applied in survey analysis. Due to inevitability of ties in most cases, *tau-b* will generally be smaller than *gamma*. However, this characteristic was found to be well anticipated by researchers who advocate the use of *tau-b* over *gamma* in questionnaire analysis (e.g. Pollock, 2005, p. 148; Le Roy, 2009, p. 194). While both authors recommend the use of the ‘more conservative’ *tau-b*, their recommendations for interpreting the strength of the measured relationship are respectively more ‘generous’ in comparison to the common frame of reference based on Cohen’s (1988) effect size thresholds. As an example, both consider correlations greater than 0.3 as strong, whereas the guidelines adopted from Cohen suggest 0.5 as lower boundary for indicating a strong relationship. As a practical example from Study I (see p. 101), the *gamma* coefficient between ‘feeling in control’ and feeling part of a creative process’ (*gamma* = 0.56, $p < 0.0001$) can be interpreted as strong when following Cohen’s guidelines. When calculating *tau-b* for the same combination (*tau-b* = 0.40, $p < 0.0001$), the proposed guidelines for *tau-b* lead to the same interpretation.

In summary, *gamma* was chosen over *tau-b* as its treatment of tied observations appeared more appropriate to the problem it was applied to. From a practical point of view, as discussed in the last paragraph, the choice had no impact on the interpretation of the study results.

Appendix E

Sound Sets (DVD)

Included with this thesis there is a DVD (wallet attached to the inside of back cover), which contains the two sound sets (Sound Set I (b): Minimal Music; Sound Set II: Electronica/Techno), which were created in *Apple's Mainstage 2.2.2* (32-bit). Each sound sets is saved as *MainStage Concert* file (.concert). It contains the programmed patches for the three instruments (sound and dial settings) per set, including the applied audio effects, mixer settings and output routing. In addition, it specifies MIDI channel and MIDI Continuous Controller (CC) number for each instrument, so that the sound set can be played from every device that outputs MIDI (e.g. MIDI keyboard, sequencer). The content of the DVD is as follows:

- Sound Set I(b)-Minimal Music.concert
- Sound Set II-Electronica Techno.concert

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